

THE DESIGN OF A THEORETICAL MODEL AND CRITERIA
FOR THE CONSTRUCTION OF A CURRICULUM
FOR PHYSICAL SCIENCE

with special reference to the teaching
of Physical Science in the Cape Province

by

SCHALK WILLEM WALTERS

Thesis presented for the degree of Ph.D. in Education
University of Cape Town

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VOLUME 1

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SUMMARY

Modern curriculum theory is an incomplete and unfinished entity, subject to much disagreement and controversy. One of the major needs in this field of Education, is for a suitable, universally acceptable theoretical model for curriculum design, and for criteria for making reasoned decisions about the various elements of the curriculum.

This study endeavoured to construct a unified model for curriculum design which both accommodates the two main, divergent current approaches to curriculum development, and conforms to the conditions of universality and applicability to all levels of education. The model also provides for criteria for making decisions on each of the five curriculum elements identified by the model.

The feasibility and viability of the model was tested by using the technique of comparative evaluation applied to the syllabus for Physical Science of the Cape Education Department. Two separate evaluations were carried out; one, completely independent of the model and criteria, made use of questionnaires to pupils, teachers and university lecturers, and the observation of classroom teaching methods; the other consisted of applying the criteria to the various components of the syllabus. The results of the two evaluations were then compared.

The findings showed that the model and its criteria are viable for the syllabus for Physical Science and that further research is indicated. It was recommended that such research should provide for the design, trial and evaluation of curriculum materials based on the proposed model, and for the extension of the model to subject areas other than the physical sciences.

In addition to the information obtained regarding the curriculum model, the investigation also produced results of immediate significance to the objectives, essential content and structure of the Physical Science syllabus in use in South Africa today.

* * * * *

The main aspects of the study and investigation may be summarised as follows:

1. THE AIMS AND PURPOSE OF THE INVESTIGATION

1.1 The original purpose of this investigation was

- (a) to select, refine and formulate criteria for curriculum evaluation from the literature, and
- (b) to evaluate the South African syllabuses for Physical Science (Higher Grade and Standard Grade) of the South African Joint Matriculation Board according to these criteria.

1.2 During the course of the literature search it became apparent

- (a) that the criteria proposed by different authors depended on the curriculum model favoured by them;
- (b) that the variety of "models" offered were basically variations of only two major curriculum models;
- (c) that these two models had sufficient common features to suggest the possibility that a single, unified model for curriculum design might be feasible.

1.3 The original aim of the investigation was thus expanded to include the following:

- (a) The design of a unified theoretical model for curriculum construction;
- (b) the design and formulation of criteria for guiding decisions on each element of the model;
- (c) a preliminary evaluation to determine the viability of the model and its criteria.

2. BACKGROUND STUDY OF CURRICULUM THEORY

2.1 The literature research also revealed that each school of educational thought created and used its own terminology and that there was no unanimity as to the place and role of curriculum studies in Education. It was thus necessary to define the various educational terms and to analyse the discipline of Education in order to obtain clarity as to which area or sub-discipline of Education curriculum studies belong. It was concluded that curriculum studies should not be approached as a separate, independent sub-discipline of Education (as is commonly done in Britain and the United States), but that it should form part of the sub-discipline of Methodology of education (Didactics) from which its principles and perspectives should be derived.

2.2 The second component of the background study comprised the following:

- (a) An analysis of the major curriculum models and their variations;
- (b) an investigation into the motives and procedures for curriculum design in the physical sciences.

3. THE DESIGN OF A MODEL FOR CURRICULUM CONSTRUCTION

3.1 After establishing the need for a theoretical model for curriculum design and summarising the major approaches to curriculum theory, the requirements for such a model were determined. The major requirements may be summarised as follows:

- (a) The model must be general and universal, i.e. acceptable and applicable to any educational system;
- (b) it should be consistent with the principles of methodology of education;
- (c) it should identify the essential elements of a curriculum;
- (d) it should provide universally valid criteria for making decisions about each curriculum element;
- (e) the model should provide for all levels of education, from pre-primary to tertiary.

3.2 A model based on these requirements was then designed. The main characteristics of the model are the following:

- (a) The model provides for and identifies five essential elements, namely, (1) aims; (2) content; (3) organization; (4) method; (5) evaluation.
- (b) The interrelationship of the five elements is identified and described.
- (c) The concepts of "teaching-learning activities", "activity range" and "activity levels" are introduced. The special relationship formed by the elements content-method-organization forms a range of teaching-learning activities. Within this activity range various activity levels, ranging from the discipline based,

highly structured, teacher-centred activities typical of tertiary education to the inter-disciplinary, child-centred, free activities of the nursery school.

- (d) A set of criteria is supplied for each element of the model.

4. CRITERIA FOR THE DESIGN OF A CURRICULUM FOR PHYSICAL SCIENCE

4.1 The following procedures were adopted in the design and formulation of criteria for each curriculum element:

- (a) The identification and extraction of criteria from the analysis of existing major curricula for physics and chemistry from Britain, Europe and the United States.
- (b) The search for criteria from educational literature representing a variety of educational thought from different countries.
- (c) Compilation of sets of "preliminary criteria" based on the classification of the criteria obtained from (a) and (b) above.
- (d) Refinement of the criteria. The refinement of the criteria was carried out after interviews and discussions with curriculum specialists from 18 countries, as well as by subsequent editing to remove any possible ambiguity in meaning, duplication of criteria and to ascertain that the criteria complied with the requirements listed in paragraph 3.1.
- (e) A final formulation of the criteria was carried out. The criteria for the different curriculum elements are listed below.

4.2 The criteria for curriculum objectives

1. Convergence: Curriculum objectives should converge into a single focus - the ultimate aim of education.
2. Validity: The objectives should be valid in the educational, societal, professional and vocational contexts.
3. Appropriateness: The objectives should be appropriate to the level of development and background of the pupils.
4. Precision: The objectives should be formulated at a sufficiently high degree of precision and specificity.

5. Comprehensiveness: The objectives should provide for a wide range of abilities, interests and values.
6. Relevance: The objectives should be relevant to the lives and life-styles of the pupils.
7. Flexibility: The objectives should be sufficiently flexible to provide for development in knowledge of the subject, the learner, aspects of education, and changing needs.
8. Realism: The objectives should be realistic and feasible, i.e. attainable in the practical teaching situation.

4.3 The criteria for the selection of content

1. Validity: the content should be valid in the sense that it is appropriate to the curriculum aims and in that it represents authentic, up-to-date knowledge.
2. Significance: The content should be significant in that it should provide for the understanding of principles and concepts and for the related, essential factual knowledge which is meaningful to the pupil, and in that it should convey the methods of the investigative procedures characteristic of the subject.
3. Balance: The content should represent an appropriate balance of scope and depth of understanding.
4. Relevance: The content should be relevant to life in general and to the life of the pupil in particular.
5. Interest: The content should take into account and provide for the interests of pupils.
6. Consistency: The various components of the content should be non-contradictory and be correlated as far as possible.

4.4 The criteria for the organization of content

1. Systematic subject structure. The subject should have a systematic structure, but not necessarily one based on the logical structure of the discipline.
2. Developmental sequence: The content should be organized to match and be compatible with the development of the pupil.

3. Cumulative learning: The organization should provide for opportunities to reinforce and apply previously acquired knowledge, to improve the pupils' mastery of this knowledge, to enrich and extend their learning, and to gain a deeper understanding.
4. Integration: The organization should provide for integration of the subject matter and subject areas.
5. Methodological progression: The organization of content should be in agreement with accepted methodological progressions, e.g. from the concrete to the abstract; from the known to the unknown; from the particular to the general; etc.
6. Practicality: The organization should take into account such factors as regional differences, climatic variations, seasonal availability of resources, the level of manipulative and other skills required, facilities, etc.

4.5 Criteria for method and teaching-learning activities

1. Goal directedness: Both teachers and learners should know and understand the objectives of every teaching-learning situation.
2. Systematic planning: Teaching-learning activities should be carefully and systematically planned for the attainment of their objectives.
3. Totality: Pupils should be aided to see each teaching-learning activity in its proper relation to the whole and to enrich their learning so that it becomes more meaningful.
4. Pupil interest: The interest of pupils should be obtained and maintained to the highest degree possible.
5. Perception: The teaching should be lifelike and involve all the sensory experiences necessary to re-create or approximate the real-life situation.
6. Activity: Pupils should be involved physically and mentally in the teaching-learning activities.
7. Individualization: Activities should provide for individual differences.

8. Humanization: The teaching should make pupils aware of and emphasise human values, relationships and interest.
9. Mastery: Teaching-learning activities should provide for guidance and consolidation.

4.6 The criteria for curriculum evaluation

1. Consistency: The evaluation should be consistent with the curriculum aims and objectives.
2. Comprehensiveness: Curriculum evaluation should provide for all aspects of the curriculum and involve all those concerned with the curriculum in all its stages.
3. Diagnostic value: The evaluation should identify possible strengths and weaknesses of the curriculum and indicate the possible reasons for such strengths and weaknesses.
4. Maximum rigour: The evaluation procedures should be designed to obtain the maximum rigour practically possible.
5. Unity: The evidence should not be limited to or be interpreted with respect to a single element of the curriculum but should be weighed in the light of the interrelationships of the elements.
6. Relatedness to practical teaching: The evaluation should relate to the practical teaching situation and, when it involves implementation, be integrated with the classroom teaching.

5. A COMPARATIVE EVALUATION OF THE CAPE CURRICULUM FOR PHYSICAL SCIENCE

5.1 The viability of the model and criteria was provisionally tested by means of a comparative evaluation of the Standard and Higher Grade syllabuses for Physical Science of the Cape Department of Education. The two evaluations consisted of (a) a criterion-independent evaluation by means of questionnaires to pupils, teachers and university lecturers, and the observation of teaching methods in the classroom; and (b) the application of the criteria to each element of the curriculum. The findings of the two evaluations were compared to determine the amount of agreement. A satisfactory agreement on comparable aspects could reasonably be interpreted as indicative of the viability of the model and criteria.

- 5.2 Eventually certain limitations inherent in the techniques employed and the actual teaching situation limited the comparison to three elements only, namely, aims, content and evaluation.
- 5.3 In addition to the data for the comparative evaluation, other information relevant to the teaching of Physical science was also obtained.
- 5.4 The application of the criteria revealed certain problems regarding formulation and interpretation and it was thus suggested that each criterion should be accompanied by a detailed explanation and a detailed guide for its application.
- 5.5 Based on the very satisfactory agreement obtained it was concluded that the model and criteria offer distinct possibilities for curriculum design and that further research is indicated.

6. ANCILLARY FINDINGS AND CONCLUSIONS

- 6.1 The evaluations revealed a number of specific weaknesses in the syllabuses for Physical Science, especially in the aims, content and organization.
- 6.2 Findings which may be important for the methodology of teaching Physical Science included (a) the equally high value of pupil experiments and teacher demonstrations as aids to understanding; (b) the effectiveness of ciné films and demonstration models in the teaching; (c) the important role of the textbook; (d) the adverse effect of the length of the syllabus on teaching method.
- 6.3 To remedy the existing lack of curriculum evaluation to some extent, it was recommended that the results of the external examinations be analysed and that the information be fed back to teachers and curriculum designers.
- 6.4 Based on the core of essential content identified by teachers and university lecturers, and to provide for the requirements of science teaching in general education, a curriculum structure consisting of a compulsory core (the essential content) and a limited number of optional units, was proposed.

Summary in Afrikaans

OPSOMMING

DIE ONTWERP VAN 'N TEORETIESE MODEL EN KRITERIA
VIR DIE OPSTEL VAN 'N KURRIKULUM VIR NATUUR- EN SKEIKUNDE

met spesiale verwysing na die onderrig van
Natuur- en Skeikunde in die Kaapprovinsie

1. DIE DOELSTELLINGS VAN DIE ONDERSOEK
 - 1.1 Die aanvanklike doel van die ondersoek was
 - (a) om kriteria vir kurrikulum-evaluering uit die opvoedkunde-literatuur te versamel, hulle te orden en, indien nodig, te herformuleer, en
 - (b) die Suid-Afrikaanse sillabusse vir Natuur- en Skeikunde (Hoër Graad en Standaard Graad) van die Gemeenskaplike Matrikulasieraad aan die hand van hierdie kriteria te evalueer.
 - 1.2 Reeds tydens die literatuurnavorsing het dit geblyk (a) dat die kriteria wat deur die verskillende skrywers voorgestel is, afhang van die kurrikulummodel wat hulle persoonlik aanhang; (b) dat die verskeidenheid van modelle wat aangebied word eintlik slegs variasies van twee basiese modelle is; (c) dat hierdie twee modelle soveel gemeenskaplike kenmerke bevat dat dit miskien moontlik sou kon wees om 'n enkele eenheidsmodel vir kurrikulumontwerp op te stel.
 - 1.3 Die oorspronklike doelstelling van die ondersoek is gevolglik uitgebrei om vir die volgende voorsiening te maak:
 - (a) Die opstel van 'n enkele teoretiese model vir kurrikulumontwerp;
 - (b) die ontwerp en formulering van kriteria om te dien as riglyne wanneer beslissings ten opsigte van elke kurrikulum-element gemaak word;
 - (c) 'n voorlopige evaluering om die lewensvatbaarheid van die model en kriteria te bepaal.

2. AGTERGRONDSTUDIE OOR KURRIKULUMTEORIE

2.1 Die literatuurnavorsing het ook aan die lig gebring dat bykans elke opvoedkundige denkrigting sy eie terminologie skep en gebruik en dat daar nie eenstemmigheid bestaan oor die plek en funksie van kurrikulumstudie in die Opvoedkunde nie. Dit was dus noodsaaklik om die verskillende opvoedkunde-terme te definieer en om 'n ontleding van Opvoedkunde as dissipline te maak ten einde helderheid te verkry oor die terrein of deeldissipline waarby kurrikulumstudie ingedeel behoort te word. Daar is besluit dat kurrikulumstudie nie as 'n afsonderlike, onafhanklike deeldissipline van Opvoedkunde (soos gebruiklik in Brittanje en die V.S.A.), beskou kan word nie, maar dat dit 'n onderdeel uitmaak van die metodiek van onderwys (Didaktiek). As sodanig is kurrikulumstudie aangewese op en onderworpe aan die beginsels en perspektiewe van die metodiek van onderwys.

2.2 'n Tweede komponent van die agtergrondstudie het die volgende behels:

- (a) 'n Ontleding van die vernaamste kurrikulummodelle en hul variante;
- (b) 'n ondersoek na die dryfvere vir en metodes van kurrikulumontwerp in die fisiese natuurwetenskapvakke.

3. DIE ONTWERP VAN 'N MODEL VIR KURRIKULUMOPSTELLING

3.1 Nadat die behoefte aan 'n teoretiese model vir kurrikulumontwerp vasgestel en die belangrikste benaderings tot kurrikulumteorie saamgevat is, is die vereistes waaraan so 'n model behoort te voldoen, bepaal. Die belangrikste vereistes kan soos volg saamgevat word:

- (a) Die model moet algemeen en universeel, d.w.s. aanvaarbaar deur en toepasbaar in enige onderwysstelsel wees;
- (b) dit moet in ooreenstemming (nie-strydig) met die beginsels van die metodiek van onderwys (didaktiek) wees;
- (c) dit moet die noodsaaklike kurrikulum-elemente identifiseer;
- (d) dit moet universeel-geldende kriteria ten opsigte van elke element voorsien;
- (e) die model moet voorsiening maak vir alle vlakke van onderwys, van pre-primêr tot tersiêr.

3.2 'n Model is aan die hand van hierdie vereistes ontwerp. Die vernaamste kenmerke van die model is die volgende:

- (a) Die model maak voorsiening vir en identifiseer vyf noodsaaklike kurrikulum-elemente, t.w. (1) doelstellings; (2) inhoud; (3) organisasie (ordening); (4) metodiek; (5) evaluering.
- (b) Die onderlinge verwantskappe tussen die elemente word geïdentifiseer en beskryf.
- (c) Die begrippe "onderrig-leer-aktiwiteite", "aktiwiteitsomvang" en "aktiwiteitsvlak" is ingevoer. Die besondere verwantskappe ten opsigte van die elemente inhoud-metodiek-organisasie vorm die breë omvang van onderrig-leer-aktiwiteite. Binne hierdie breë aktiwiteitsomvang bestaan daar verskeie moontlike aktiwiteitsvlakke wat kan wissel van die streng geordende, onderwysergerigte, dissiplinêre benadering kenmerkend van tersiêre onderrig, tot die interdissiplinêre, kindgerigte, vrye aktiwiteite van die kleuterskool.
- (d) Voorsiening word gemaak vir 'n stel kriteria ten opsigte van elke element van die model.

4. KRITERIA VIR DIE ONTWERP VAN 'N KURRIKULUM VIR NATUUR- EN SKEIKUNDE

4.1 Die volgende werkswyse is gevolg om kriteria vir elke kurrikulum-element te ontwerp en te formuleer:

- (a) Die belangrikste bestaande kurrikula vir fisika en chemie uit Brittanje, Europa en die V.S.A. is ontleed ten einde moontlike kriteria te identifiseer en uit te lig.
- (b) Vakliteratuur wat verteenwoordigend van verskeie lande en denkrigtings is, is nagegaan vir moontlike kriteria.
- (c) Stelle "voorlopige kriteria", saamgestel en georden uit bogenoemde bronne, is opgestel.
- (d) Ná onderhoude en samesprekings met kurrikulumdeskundiges uit 18 verskillende lande, is die kriteria verbeter en krities geredigeer om moontlike teenstrydighede en duplisering uit te skakel en om te verseker dat hulle voldoen aan die vereistes genoem in paragraaf 3.1.
- (e) 'n Finale stel kriteria is daarna geformuleer.

Die finale kriteria vir elke kurrikulum-element word hieronder saamgevat.

4.2 Die kriteria vir kurrikulumdoelstellings

1. Konvergensie (in die uiteindelijke doelstelling van onderwys).
2. Geldigheid (in die opvoedkundige, professionele, maatskaplike en beroepsverband).
3. Toepaslikheid (ten opsigte van die ontwikkeling en agtergrond van die leerlinge).
4. Presisie (ten opsigte van duidelike formulering en spesifisiteit).
5. Omvangrykheid (ten opsigte van voorsiening vir 'n wye spektrum van vaardighede, belangstellings en waardes).
6. Relevansie (ten opsigte van die lewenswyses van die leerlinge).
7. Buigsaamheid (ter wille van ontwikkelinge in kennis van die vak, die leerling en die opvoedkunde, en veranderende behoeftes).
8. Realisme (ten opsigte van bereikbaarheid in die praktiese onderwys-situasie).

4.3 Die kriteria vir die keuse van inhoud (leerstof)

1. Geldigheid (ten opsigte van toepaslikheid met betrekking tot die kurrikulumdoelstellings en in soverre dit egte, hedendaagse kennisinhoud behels).
2. Sinvolheid (ten opsigte van die voorsiening van begrippe en die verwante, noodsaaklike feitekennis wat vir die leerling betekenis het, en ten opsigte van die wyse waarop die ondersoekmetodes wat kenmerkend van die vak is, oorgedra word).
3. Balans (ten opsigte van die omvang van die inhoud en die diepte van begrip).
4. Relevansie (ten opsigte van die verband met die daaglikse lewe in die algemeen en die lewe van die leerling in die besonder).
5. Belang. (Die inhoud moet rekening hou met en voorsiening maak vir leerlingbelangstelling.)
6. Nie-strydigheid (in die verband dat die afsonderlike leerstof-inhoud nie teenstrydig moet wees nie en so ver doenlik met mekaar moet integreer.)

4.4 Die kriteria vir leerstofordening (organisasie)

1. Sistematiese vakstruktuur (wat nie noodwendig op die logiese struktuur van die vakdissipline gebaseer is nie).
2. Ontwikkelingsvolgorde. (Die leerstofordening moet pas by en in pas wees met die ontwikkeling van die leerling.)
3. Kumulatiewe leer (d.w.s. die voorsiening van geleenthede om verworwe kennis te laat insink en toe te pas, om die kennis behoorlik te bemeester, te verryk en uit te brei, en om grondiger begrip te ontwikkel).
4. Integrering (van leerstofeenhede en vakgebiede).
5. Metodologiese volgorde. (Die leerstofordening moet ooreenstem met aanvaarde metodologiese volgordes, bv. van die konkrete na die abstrakte, van die bekende na die onbekende, van die besondere tot die algemene, e.s.m.)
6. Praktiese doenlikheid (deur rekening te hou met streeksverskille, klimaatswisseling, beskikbaarheid van fasiliteite, e.s.m.).

4.5 Die kriteria vir metodiek en onderrig-leer-aktiwiteite

1. Doelgerigtheid. (Sowel leerlinge as leerkragte moet kennis dra van die doelstellings van elke onderrig-leer-situasie en dit begryp.)
2. Sistematiese beplanning (met die oog op die verwesenliking van die onderrig-leer-doelstellings).
3. Totaliteit. (Leerlinge moet gelei en gehelp word om elke onderrig-leer-aktiwiteit in sy verband met die geheel te sien en om hulle kennis te verryk sodat dit meer sinvol word.)
4. Leerlingbelangstelling (moet gekweek, verkry en behou word).
5. Aanskouing. (Die onderrig moet so ver doenlik lewensgetrou wees en alle sintuiglike aktiwiteite betrek wat nodig is om die werklikheid te herskep of na te boots.)
6. Aktiwiteit. (Leerlinge moet fisies en verstandelik aktief deel hê aan die onderrig-leer-aktiwiteite.)

7. Individualisering (maak voorsiening vir verskille tussen leerlinge).
8. Humanisering (deur beklemtoning en bewusmaking van menslike waardes, verhoudings en aspekte met betrekking tot die vak).
9. Baasraking (deur die voorsiening van die nodige studieleiding en geleentheid vir konsolidasie).

4.6 Die kriteria vir kurrikulum-evaluering

1. Nie-strydigheid. (Die evaluering moet in ooreenstemming met die kurrikulumdoelstellings wees.)
2. Omvattendheid. (Alle aspekte van die kurrikulum sowel as alle persone betrokke by die ontwerp en toepassing daarvan, moet betrek word.)
3. Diagnostiese waarde. (Die evaluering moet die verdienstes en tekortkominge van die kurrikulum kan uitlig en ook aanduidings verskaf van die redes vir sodanige verdienstes of gebreke.)
4. Gestrenghed. (Die hoogste mate van geldigheid, betroubaarheid, objektiwiteit, ens., moontlik, moet nagestreef word.)
5. Eenheid. (Evaluering moet nie beperk word tot 'n enkele kurrikulum-element nie, maar die gegewens moet oorweeg word in die lig van die onderlinge verwantskappe tussen die verskillende elemente.)
6. Praktiese verband. (Die evaluering moet sy verband met die praktiese onderrigsituasie behou en wanneer dit te doen het met invoering en toepassing, behoort die evaluering met die klaskameronderrig geïntegreer word.)

5. 'N VERGELYKENDE EVALUERINGS VAN DIE KAAPLANDSE KURRIKULUM VIR NATUUR- EN SKEIKUNDE

- 5.1 Die lewensvatbaarheid van die kurrikulum-model en kriteria is aan 'n voorlopige toets onderwerp. Die metode van vergelykende evaluering is vir hierdie doel op die Kaaplandse sillabusse vir Natuur- en Skeikunde (Hoër en Standaard Graad) toegepas. Twee soorte evaluering is gebruik, nl. een wat onafhanklik van die kriteria was en gebruik

gemaak het van vraelyste aan leerlinge, onderwysers en universiteitsdosente, en 'n tweede wat die toepassing van die kriteria op die sillabusse en onderrig behels het. Die resultate van die twee evalueringe is vergelyk en daar is aangeneem dat 'n bevredigende ooreenstemming tussen die twee metodes op die lewensvatbaarheid van die model en kriteria dui.

- 5.2 As gevolg van sekere beperkinge inherent aan die evalueringstegnieke en die praktiese onderrigsituasie is die voorgenome vergelyking uiteindelik beperk tot drie elemente, nl. doelstellings, inhoud en evaluering.
- 5.3 Bo en behalwe die gegewens wat betrekking op die vergelykende evaluering het, is ook ander inligting wat vir die onderrig van Natuur- en Skeikunde van belang is, uit die ondersoek verkry.
- 5.4 Die toepassing van die kriteria het probleme ten opsigte van interpretasie en formulering opgelewer en daar is gevolglik aanbeveel dat elke kriterium voorsien behoort te wees van 'n volledige uiteensetting en riglyne vir die toepassing daarvan.
- 5.5 Na aanleiding van die besonder bevredigende ooreenstemming wat die vergelykende evaluering opgelewer het, is daar tot die gevolgtrekking geraak dat die model en kriteria besliste moontlikhede vir kurrikulumontwerp inhou en dat verdere navorsing uitgevoer behoort te word.

6. BYKOMSTIGE BEVINDINGE EN GEVOLGTREKKINGS

- 6.1 Die evalueringe het 'n aantal spesifieke gebreke ten opsigte van die doelstellings, inhoud en ordening van die sillabusse vir Natuur- en Skeikunde blootgelê.
- 6.2 Die volgende bevindings kan moontlik van besondere belang wees vir die onderrigmetodiek van Natuur- en Skeikunde:
 - (a) Die gelyke en besonder hoë waarde van leerlingeksperimente en onderwyserdemonstrasies vir begripsvorming;
 - (b) die besondere doeltreffendheid van rolprente en demonstrasie-modelle as onderrighulpmiddels;

- (c) die belangrike rol van die handboek;
- (d) die uitwerking van die lengte van die sillabus op onderwysmetodes.

- 6.3 Ten einde die heersende gebrek aan kurrikulum-evaluering tot 'n mate te verhelp, is aanbeveel dat die uitslae van die jaarlikse eksterne eksamens ontleed en verwerk word en dat die inligting wat só verkry word, aan leerkrigte en kurrikulumontwerpers beskikbaar gestel word.
- 6.4 Op grond van die kern van noodsaaklike inhoud wat deur onderwysers en universiteitsdosente uitgelig is, en om te voorsien in die vereistes van wetenskaponderrig vir opvoedende onderwys, is 'n kurrikulumstruktuur bestaande uit 'n verpligte kern van noodsaaklike leerstof en 'n beperkte aantal opsionele studie-eenhede, voorgestel.

PART I: THE THEORETICAL BASIS OF CURRICULUM STUDIES

CHAPTER I

A REVIEW AND RATIONALE

Because of the need for leadership and guidance in the development of science curricula (we) need to keep the total picture of science education in focus, to seek to identify the over-arching themes in science, to clarify the goals, and to establish criteria for sound curriculum development in science.

- The Science Teacher, December 1962

On October 4, 1957, the Russians succeeded in putting a small sphere of very nearly 84 kg into orbit around the earth. The faint and monotonous 'beep-beep' of the world's first artificial satellite had a much greater impact on the teaching of the natural sciences than the devastating roar of the explosion of the first atomic bomb. Until then most people in the West had comforted themselves with the belief that their own science and technology were ahead of those of the Russians; with the launching of the sputnik, this belief was rudely shattered. Especially in the United States of America scientists, educationists and the public were suddenly awakened from an educational complacency caused by an apparently limitless progress in technology, into a wide-awake state of alarm, fear and sudden activity.

The reaction was immediate and is now educational history. After initial accusations and counter accusations between university and school, the variety of causes and solutions offered was analysed and discussed in an atmosphere of greater calm and purpose. The situation, in the words of Professor Finlay of the American Physical Science Study Committee (PSSC), called for "a massive attack combining the insights of teachers, scholars and other specialists".¹

From this "massive attack" of American educationists emerged curriculum approaches such as the Physical Sciences Study Committee's physics course (PSSC)* and the chemistry courses of the Chemical Bond Approach (CBA)

* PSSC actually dates from 1956, before the launching of Sputnik.

and the Chemical Education Materials Study (CHEM Study), each one a complete package deal of textbook, laboratory manual, teachers' guide, apparatus, films and aids.

Significant, also, in the reshaping of the American policies of science education, was the initiative taken by such high-calibre scientists as J.R. Zacharias of the Massachusetts Institute of Technology and Glen Seaborg, Nobel Laureate in Chemistry, 1951. The universities were indeed strongly represented in the policy making and preparation of materials.

Neither the problem of developing suitable science curricula, nor the sense of urgency in putting them into practice, was confined to the United States of America. The need for better science teaching had long been recognised in all industrial countries whose prosperity so largely depends on an adequate and steady supply of scientists and technologists. The added stimulation provided by the "Sputnik shock" had widespread results in many parts of the world: in Australia large parts of the school science curricula were refashioned along American lines,² in Europe the Organisation for Economic Co-operation and Development (OECD) pooled ideas from their member countries³ and in Britain the Nuffield Foundation funded a science teaching project.^{4,5}

In South Africa, too, the need for a change in the approach to, and in the content of, science teaching was being felt. As early as the late 1940's and the early 1950's H.P. Malan⁶ and others⁷ criticised the teaching of senior school science and clamoured for a more "modern approach", but it was only as a result of the backwash from the post-sputnik activities in the United States that the South African Chemical Institute requested the National Bureau for Educational and Social Research to conduct an investigation into the status of science teaching in South Africa. The results of this survey, conducted in 1961, were published in 1964.⁸ This was followed by an investigation on behalf of the South African Joint Matriculation Board (JMB) by Professor H.S. Steyn⁹ into the transition between school and university. This study revealed, inter alia, that the failure rate at university level was much greater among science students than arts students.

Consequently a Joint Syllabus Committee under the JMB, entrusted with the task of drawing up new syllabuses for Physics, Chemistry and

Physical Science (a combined physics-chemistry course), was appointed and started work in November 1964. In the meantime the South African Chemical Institute and the South African Institute of Physics drafted syllabuses for Chemistry and Physics respectively, and by virtue of the majority representation of the universities in the Joint Syllabus Committee, succeeded in having these syllabuses accepted with only minor modifications. A syllabus for Physical Science, the subject offered by the majority of high school pupils in South Africa at that time, was obtained by simply combining the syllabuses for Chemistry and Physics, with some material indicated as "not for examination purposes" in an effort to keep the content within the limits of a two year course.¹⁰ The final, so-called core syllabus for Physical Science was finalised on November 24, 1965, and introduced into South African Provincial High Schools in 1968 (Transvaal and Natal) and in 1969 (Cape Province and Orange Free State).

This new syllabus for Physical Science (the 1965 syllabus) was modelled mainly on American lines in content, and the influence of PSSC, CBA and CHEM Study was apparent. Furthermore, as a consequence of the majority representation of the university subject specialists in the Joint Syllabus Committee, the syllabus was clearly designed with the needs of the university-bound science student in mind. No provision was made for the non-science university entrant, nor for the majority of high school pupils who did not intend following academic careers. Although the content was based on that of the American programmes, no supporting information and services as to method, materials and aids were developed by the Committee. Implementation was left largely to the teachers and the various departments of education.

The introduction of a system of differentiated education¹¹ necessitated the revision of the 1965 syllabus in order to provide for Higher and Standard Grades of instruction and examination. These revised syllabuses, published in 1972,¹² were introduced in Provincial High Schools in 1973 (Natal and Transvaal) and 1974 (Cape Province and Orange Free State). The national system of differentiated education also provided for four school phases, viz. (a) Junior Primary School Phase (first three years of primary education); (b) Senior Primary School Phase (final three years of primary education); (c) Junior Secondary School Phase

(first three years of secondary education); (d) Senior Secondary Phase (final three years of secondary education). The corresponding age ranges are, respectively, (a) 6/7 - 8/9 years; (b) 9/10 - 11/12 years; (c) 12/13 - 14/15 years; (d) 15/16 - 17/18 years. Education is compulsory up to the end of the year in which the pupil turns 16, that is, usually during the second year of the Senior Secondary Phase.

The new higher and standard grade syllabuses for Physical Science (the 1972 syllabuses) thus provided for a three year course of study, whereas the 1965 syllabus only provided for a two year course. However, the final two years of the 1972 syllabuses, on which the final examinations are set, retained virtually the same material as that prescribed by the 1965 syllabus, including the aims formulated for the latter. As far as could be ascertained no feedback from the results of examinations set on the 1965 syllabus or from teachers was utilised in drawing up the 1972 syllabuses.¹³

Even before the 1972 syllabuses could be examined by the Cape Province and Orange Free State, certain deficiencies became apparent and the syllabus content had to be reduced by the exclusion of some topics or parts of topics. These reductions were finalised on September 16, 1976.¹⁴

From this brief review it would seem as if the South African high schools are still involved in the teaching of Physical Science which is essentially the adapted product of the original American "panic curricula". However, the way in which each country implements a specific content of or approach to teaching is determined very largely by its existing educational structure. In the United States of America physics and chemistry are each concentrated into single years of study, whereas in South Africa these two subjects are offered as a combined course, Physical Science, of three years' duration; and this is preceded by three years of General Science which includes a fair proportion of introductory physics and chemistry.

Although dissatisfaction with the present syllabuses and with the quality of the teaching has been expressed in various circles - ranging from such an august body as the Scientific Advisory Committee to the Prime Minister, to letters in the popular press¹⁵ - the main objections seem

to be based on evidence such as the decreasing popularity of the sciences, both at university and school level, and on the excessive work load of high school pupils, rather than on specific criticism of the content, approach and method of the subject. Current research and investigations seem to be concentrating on determining the status quo and eliciting the opinions of teachers¹⁶ rather than on proper diagnosis and remedy based on the development and controlled trial of suitable materials and alternatives. There are, however, encouraging signs of efforts in this direction¹⁷ and it is hoped that the development and trial of curriculum materials in some selected schools in the Cape Province and Transvaal will not be limited to these provinces only, but will be made available to all those concerned with the design, development and implementation of physics and chemistry curricula in South Africa.

* * * * *

Proper curriculum development, however, requires more than trial and error methods. As will be argued later (Chapter 3), our present knowledge of the theoretical bases for effective curriculum design is unstructured and often contradictory. Curriculum theory is still in its infancy. Among other aspects, it lacks suitable, universally valid criteria for the selection of curriculum elements such as aims, content, organisation and methodology. Only by structuring and formulating valid criteria and by evaluating the present curricula, as well as feedback from experimental curricula against these criteria, can a reasonable assessment of the suitability and effectiveness of a curriculum for Physical Science be attempted.

From this statement emerges the two-fold purpose of this investigation, namely,

- (a) to attempt the selection and formulation of valid curriculum criteria, and
- (b) to evaluate the aims, content, organisation and teaching of the present syllabuses for Physical Science on the basis of these criteria.

The original intention of this study was to extract criteria from the existing literature and curricula, to subject them to a critical analysis

and then to select those found to be valid on theoretical and practical grounds. These selected criteria were then to be used for the evaluation suggested in (b) above, by means of questionnaires to pupils, teachers and university lecturers involved in the teaching of first year students in physics and chemistry.

Already during the course of the literature research it became apparent (a) that criteria depended to a large extent on the curriculum model itself; (b) that the many "models" of curriculum design offered by the various authors and curriculum developers turned out to be variations of basically only two major models; (c) that even these two models had many common features which suggested the possibility that a single, unified model could be constructed. It thus became necessary to adapt the original investigation in order to attempt the development of a suitable theoretical model for curriculum design.

For this purpose the following procedures were adopted:

1. Analysis of existing science curricula from a variety of countries in order to identify the different models of curriculum design used as bases for their development.
2. Observation of the classroom implementation of some selected curricula in order to judge their applicability and effectiveness in actual practice.
3. Interviewing curriculum developers, educationists, physicists, chemists and teachers, mainly to determine their views on models for curriculum design and the criteria to be applied in the process of curriculum development.
4. The structuring of a tentative unified model for curriculum design.
5. The formulation of possible criteria for curriculum design.
6. The evaluation of the "curriculum" for Physical Science (the 1972 syllabuses) as taught in provincial high schools in the Cape of Good Hope.

At the outset it was fully realised that such a model and criteria can only be tentative and that they may be amended, refined or rejected as knowledge and understanding of the related fields, such as theories of

cognitive development, learning and instruction, develop and expand. Also, by limiting the field of study to curricula for the physical sciences and to its South African context, many of the results and conclusions may not be universally applicable to general curriculum theory. It will be argued, however, that scientific theory develops in a cumulative manner, drawing upon a variety of contributions from many different researches. It is hoped that this limited study, too, will contribute, albeit in a very minor way, to the search for an acceptable curriculum theory.

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CHAPTER 2CURRICULUM STUDY AS AN ASPECT OF THE METHODOLOGY OF EDUCATION

Curriculum study is a separate
pedagogic science ...

- Jos. Aarts¹

1. INTRODUCTION

- 1.1 It has been said that old words grow as men are compelled to express new ideas in terms of them, and few definitions have a virile life of even a score of years. This seems to be specially true of Education or Pedagogy - two terms that themselves are not always accepted as synonyms.

Educationists in South Africa can, because of a dual cultural inheritance from both Continental Europe and Great Britain, and by having two official languages which provide access to publications of Anglo-American and Dutch-German origin, draw perhaps more readily on a greater variety of ideas and approaches in the field of Education. There are, however, also a number of disadvantages attached to drawing from this larger pool, particularly regarding nomenclature and delicate shades of difference in meaning of certain terms used in educational publications. Whether some of these differences in meaning are indeed the result of the "growth of old words in order to express new meanings", or rather an artificial creation of educational-technical terminology, is a moot point. For the purpose of this dissertation, however, it will be necessary to clarify and define certain terms in order to remove any ambiguity in meaning and to avoid possible misinterpretation.

- 1.2 Wherever the following terms occur in the text, they will be used to express the meanings ascribed to them below. These terms may, however, be used differently in some direct quotations. The synonyms given, as well as the differences in interpretation, should be kept in mind wherever direct quotations from other publications occur.

- 1.2.1 Education (spelt with a capital E in the text): the science dealing with education (see 1.2.2); synonym: pedagogics.
- 1.2.2 education (spelt with a lower case e in the text, to distinguish this term from "Education" in 1.2.1 above): the practice of educating; synonym: pedagogy.
- 1.2.3 education(al)ist: one who practises the science Education; synonym: pedagogician.
- 1.2.4 educator: one who educates by virtue of a knowledge of Education, or of aspects of Education, either formally or informally acquired; synonym: pedagogue.
- 1.2.5 educational: adjective derived from Education (the science); synonym: pedagogical.
- 1.2.6 methodology of education: the part-discipline of Education which deals with the questions of why, how and by what means a child is taught or should be taught; i.e. the science of the means and methods of teaching and instruction in its educational context and in all its aspects. This term should not be confused with "educational methods" or "teaching methods" (see 1.2.8 below).
Synonyms: general methodology (Duminy)²; didactics.
- 1.2.7 special methodology: the methodology of education (as defined in 1.2.6 above) of special fields of education, e.g. subjects or subject areas, the gifted, the retarded, the physically handicapped, etc.; synonym: special didactics.
- 1.2.8 teaching method(s): the ways, means, techniques and strategies of teaching and instruction; synonyms: educational method; teaching method; methodics.
- 1.2.9 course: a collection and sequence of subjects for one or more years of study, selected or compiled from a variety of subjects offered by an educational institution, e.g. a school.
- 1.2.10 syllabus: an organised selection of the content of a subject, or part of a subject; a list of subject content.
- 1.2.11 curriculum: the description and systematic arrangement of the aims, content, activities, teaching methods and evaluation procedures for a subject or part of a subject. It should be noted that the term "curriculum" is often used as a synonym for both "course" and

"syllabus", but "whereas the latter is solely concerned with content, 'curriculum' suggests a programme of activities or learning experiences; it is not, then, just a matter of prescribing content but also of stipulating how it is to be handled".³

2. THE NATURE AND SCOPE OF METHODOLOGY OF EDUCATION

2.1 Education and its part-disciplines

2.1.1 Education as a science

The field of science, it has been said, is unlimited: its material is endless; every group of natural phenomena, every phase of social life, every stage of past and present development is material for science. The unifying factor in all science is its method, not its material.

Thus the student who classifies facts of any kind, who discerns their mutual relationships, describes their sequence, constructs a mental model, or embarks on any of the activities of practical investigation and of logical and imaginative reasoning, is applying scientific method and therefore practises science. The material of science is co-extensive with the whole physical universe as it now exists, as well as with its past history and the history of all life. Thus it is not the facts and knowledge themselves which make science, but the method by which they are dealt with.

To state or infer that there are certain fields of study - Education for instance - from which science is excluded, wherein its methods have no application, is therefore to state that the rules of methodical observation and of logical thought do not apply to the facts and observations which belong to such studies.

If Education, as revealed by its literature, is viewed against this criterion, it would seem as if each educationist, or school of educational thought, has an own system which to a large extent excludes that of others. Hence it may be concluded by some that Education is built either on quicksand or on air. Either educationists start from no foundation in observed facts at all or,

more likely, a superstructure, made rigid by convention and time, has been erected before a basis has been found for the accurate classification and interpretation of the observed facts. Perhaps the reason for the existence of such a superstructure could be found in the simultaneous emergence of Man and the onset of education, long before Man had developed the methods of science and even longer before he had started to apply these methods to fields other than the pure physical and biological world.

The main attempt to establish Education as a science, based on what actually happens during the educational process, was that of educationists like Kohnstamm, Waterink and Langeveld. They endeavoured to structure Education as a science by taking the phenomenon "education" - as a universal human activity - as their point of departure and to subject this observed phenomenon to a systematic, scientific analysis, free from the influence and interference of any particular dogma, creed, philosophy of life or political or other system.

However commendable this effort may be, the following brief analysis reveals that this "phenomenological approach", as expounded by some of its protagonists, does not meet the requirements of the methods of science. Gunter⁴, for example, states that "pedagogics is therefore a practical, partly descriptive and partly normative, human science". In this interpretation of Education as a science the non-scientific nature is revealed: science is not practical, i.e. it does not have as one of its primary aims the supply of useful knowledge; neither is it normative, as it does not purport to make value judgments.

Viljoen⁵ states that "phenomenology must be seen as a counter-movement, which originated as a protest against the naturalistic view on reality, which is called scientism among the human sciences. This absolutism of nature ... denies that man is anything else but a product of or an extension-piece of nature".

As a counter-movement phenomenology has made important contributions to Education. However, a purely phenomenological theory of Education is "of a formally descriptive nature; as such it is poor in concrete content and thus, to a large extent, general and colourless. It thus requires supplementation and completion by giving it content; it must be concretized and particularized with the help or contribution of certain normative sciences as well as specific, empirical

sciences - contributions which materially supplement and enrich the phenomenological description of educational reality and therefore render it more useful and effective."⁶ These shortcomings are usually ignored by the South African proponents of the phenomenological approach and they tend to reject all the contributions of the empirical sciences to Education. They severely object to, what they call, "the quantification of man", and, apart from a few exceptions, such as Professor E.H. Venter, they reject the synthesis of phenomenological and empirical methods. They tend to ignore that science, through its methods, does not deny, but limits: Science does not deny the existence of problems which may be classified as "outside the realms of pure science". In these fields science can only state its ignorance and perhaps provide such information on aspects of human behaviour which may, or may not, contribute to the eventual understanding of the structure of a particular human science. The point of view offered here is that until the scientific study of Education, both by observation and experiment, has advanced immensely beyond its present limits, science can only plead ignorance to the majority of educational problems. But to brand the contribution of the empirical sciences to some aspects of Education, however limited these contributions may be, as a denial that man is anything else but a product of nature, is in itself unscientific. A science operates within its limitations. These limitations must be recognised and understood when evaluating the contributions offered by the science concerned. Characteristic, too, of publications on the phenomenological approach to Education, is the inclusion of arguments to show that the approach and method followed are those of a pure science. Texts and treatises on, say, physics, chemistry, botany, psychology, philology, etc., do not as a rule start off by explaining in detail why they should be regarded as sciences; their scientific nature is made evident by the scientific methods of study and investigation employed. In sharp contrast to this the majority of publications dealing with the phenomenological approach to pedagogics in this country, introduce the structure of their science by lengthy arguments to justify its status as a science, to show that "... the phenomenological approach (is) the method par excellence ... to obtain autonomous status equalling that of natural sciences".⁷ The pursuit of academic status as a motive for scientific enterprise must be questioned; the nature and structure of the approach should be evident from its methods of investigation and reasoning rather than from a justification of its approach and methods.

In addition, a science does not hesitate to draw upon the results of other disciplines: physics employs the tools of mathematics; chemistry does not suffer by using the results and methods of physics; the life-sciences owe much of their rapid expansion to knowledge from the field of chemistry. Thus a statement like "Pedagogics is no longer regarded as eclectic science, collecting data from other sciences"⁸ is a denial of the method of science itself.

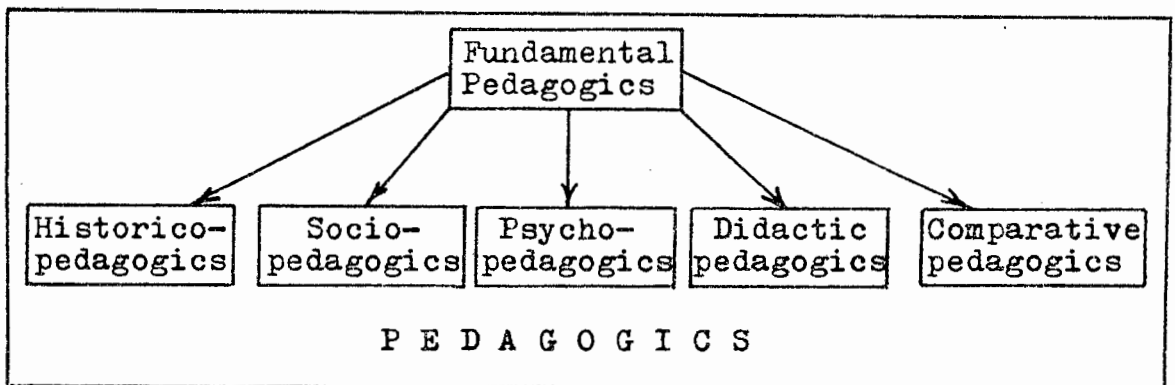
At this stage in its development Education can only be regarded as an incomplete science, which finds itself in the stage of gathering evidence and information, rather than of drawing final conclusions, or of erecting universally valid theories. In this process of development and of obtaining and testing evidence, the educationalist should not reject the findings of other approaches and sciences out of hand. Their contributions should rather be welcomed, carefully evaluated and tested in the educational situation and only then be conditionally accepted, adapted, rejected or filed away for future evaluation in the light of possible new evidence. One cannot deny that the different approaches to the study of education - be it idealistic, naturalistic, humanistic or phenomenological - all have contributed to our present understanding of this field of knowledge. Both acceptance and rejection of these contributions should, however, at this embryonic stage in the development of the science of Education, be conditional only: the willingness to change, modify or reject theories and models in the light of new evidence is one of the characteristics of science.

2.1.2 The part-disciplines of Education

All scientific disciplines comprise a number of specialised fields of study, or part-disciplines. Very often these part-disciplines were studied and investigated independently and separately, and only afterwards, when the different relationships and links became clearly understood, were they combined into a unified discipline or science. It is suggested that, in its present state of development, this situation also applies to Education.

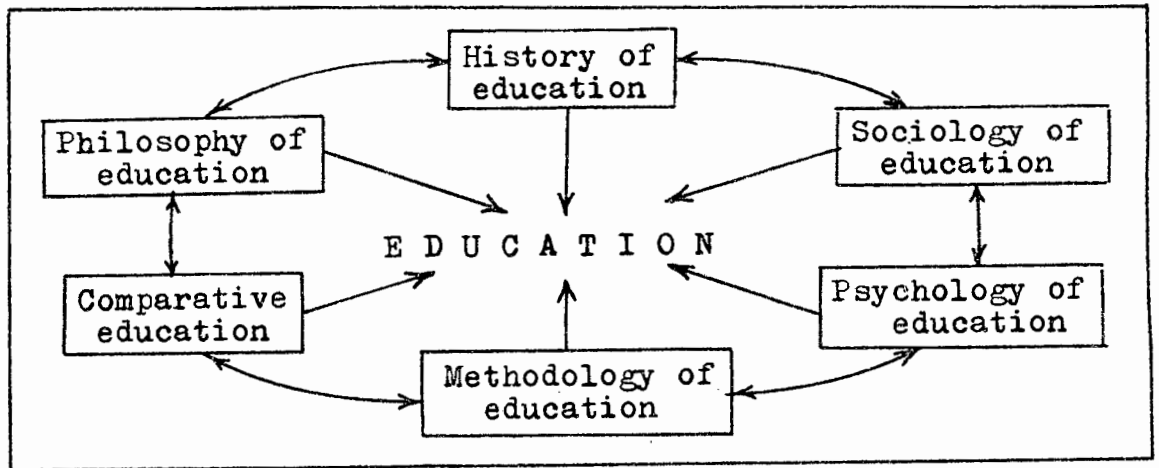
The premise is put forward that only by the investigation into and the study of the part-disciplines of Education, as well as by making judicious use of the data provided by related sciences, may the structure of Education eventually become clear. In suggesting this approach it is realised that the limitations of human understanding and the complex nature of human interactions may prove to be ineluctable barriers to the final revelation of this structure. These possibilities should not, however, prevent the scientific investigator from embarking on or proceeding with his inquiries. The history of science clearly shows that all scientific progress came about by the work of those who, in the words of Galileo, were unwilling to set limits to the human intellect.

This premise thus rejects the formulation of fundamental pedagogical categories subject to which the part-disciplines are allowed to operate. The point of view offered is rather the opposite: only by and through the information gathered in the part-disciplines may the structure of Education as a science eventually be understood.



- (a) The structure of pedagogics (Education) based on the phenomenological approach: pedagogical categories formulated by Fundamental pedagogics prescribe and limit the operation of the other part-disciplines of Education.

Fig. 2.1(a)



- (b) A proposed structure for the development of a science of Education: the eventual structure of the science will be determined by the contributions from the different, inter-related part-disciplines.

Fig. 2.1 (b)

In order to know what type of information could be obtained from the different sub-disciplines, it will be necessary to indicate briefly what they are and to describe their fields of study. The following sub-disciplines are at present generally recognised:

- 2.1.2.1 History of education (historico-pedagogy) can be described as that part-discipline of Education whose field of study is the analysis of the development of educational ideas and their implementation through the ages. The record and study of the history of educational practice should not be included in this part-discipline since it belongs to the field of the historian.
- 2.1.2.2 Philosophy of education (theory of education; fundamental pedagogy) deals with the essential nature and purpose of education as well as with the influence of the various "isms" - philosophies, religions, social and political systems - on education.
- 2.1.2.3 Psychology of education (psycho-pedagogy; empirical pedagogy) is the study of the child (educand) in the educational situation, i.e. of the data and principles related to problems such as growth and development in their educational context.

- 2.1.2.4 Sociology of education (socio-pedagogics) is concerned with the study of social relationships and interactions in the educational situation.
- 2.1.2.5 Comparative Education is, as its name implies, a comparative study and analysis of systems of education, including school systems.
- 2.1.2.6 Methodology of education (didactics) has already been described in paragraph 1.2.6 as the "science of the means and methods of teaching in its educational context and in all its aspects". In the following paragraphs the nature and scope of Methodology of education, will be discussed in greater detail.

2.2 Methodology of education as a part-discipline of Education

2.2.1 The problem of nomenclature

Many works on pedagogics devote pages to arguments designed to show that Methodology of education has a limited meaning and that this term refers only to "the theory of ways and means of presenting a lesson".⁹ The South African proponents of the phenomenological approach to Education advocate the term "didactics" to describe the theoretical science "of learning and instruction, directed towards the forming of the whole personality".¹⁰

Duminy¹¹ states that "It is remarkable that the English-speaking educational world hardly knows and very seldom uses the word didactics". In line with the very marked emphasis on the phenomenological approach to Education in so many universities and colleges in this country, he goes on to say that "General didactics is a broader concept than general method ("methodology of education"). General didactics is a theory (sic) which concerns itself with the field of teaching as a whole".¹²

If, however, one turns to the actual "English-speaking educational world" one finds the following established usage of the word "didactic": a term used to describe an authoritative style of teaching in which statements of accepted ideas, facts, etc. are made without giving the learner the opportunity to discover the supporting evidence.¹³ This usage implies a negative connotation to the word "didactic" and the term "didactics".

Since both the terms "methodology of education" and "didactics" may be defined by an educationist to include all those aspects of this part-discipline he wishes to emphasise, any detailed discussion of their relative merits is futile. However, as the word "didactic" has an established usage and meaning in English, it would be difficult to justify the introduction of "didactics" in the place of "methodology of education". The latter term is therefore preferred and retained. Where "didactics" occurs in direct quotations, these two terms will be interpreted as being essentially identical in meaning.

2.2.2 The nature of methodology of education

2.2.2.1 Introductory

Education is primarily the task and responsibility of the parent, and its basic and fundamental aim is simply survival*. With the development of Man, with the increasing complexity of the life and society he is perpetually creating and with the growth and development of more specialised needs and conditions for his continued survival as an uniquely human being - i.e. human in all its aspects and not merely as the organism homo sapiens - this primary educational task gradually expanded beyond the knowledge and abilities of the parent. Consequently a secondary educational task had to be introduced in order to provide for continued survival. This secondary extension of the educational task is delegated by the parents, as a part of society, to the specialised educator, i.e. to the school.

Although the task of the school is to continue the education of the whole child, its emphasis is on the imparting and development of knowledge and skills, i.e. on teaching and instruction. Obviously one cannot have education for survival without teaching. Methodology of education concerns itself with this teaching aspect of the more comprehensive process of education.

2.2.2.2 Methodology of education described

Although the sphere of methodology of education is limited to the teaching aspect of the educational process, there are so

* This statement of aim is discussed more fully in Part II, Chapter 5.

many factors involved in this single aspect that the field of study remains vast. The teaching task involves, for example, the teacher, the pupil, the aims and objectives, the content and its organisation, the methods, the means and media of teaching, the evaluation and assessment of its outcomes, and remedial procedures.

Any definition of methodology of education should provide for all these aspects. Thus, methodology of education may be described as that science which is concerned with investigation and research into teaching in its educational context and in all its aspects.

2.2.2.3 Methodology of education - an applied science?

From the description given above it may be inferred that methodology of education is an applied science concerned only with actual teaching practice. Such a conclusion would be wrong and limiting. The purpose of methodology of education is to erect generally applicable and educationally acceptable structures, models or theories of the teaching aspect of education. The specialised and practical aspects of teaching are, in turn, based on these general theoretical structures, as is indicated in Figure 2.2

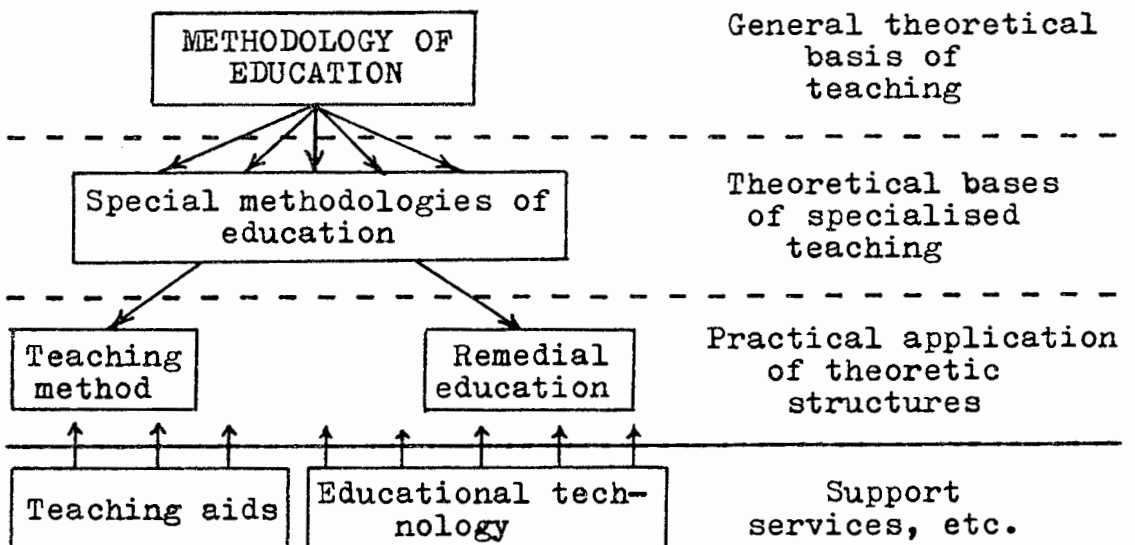


Fig. 2.2

2.2.2.4 The relationship between methodology of education and the other part-disciplines of Education

The many-faceted and complex nature of methodology of education is further revealed by the close relationship between itself and the other part-disciplines of Education. The inter-relationship and interaction between teacher and pupil relate to the field of educational sociology; knowledge of the pupil and of the learning process implies drawing on the field of psychology of education; the aims of teaching should be in line with the aims of education as evolved by philosophy of education; the history of education reveals aspects of the success or failure of methodological structures of the past; comparative education provides information about systems suitable for the application of the principles of methodology of education. Even other disciplines from outside the field of Education may contribute to the development of a methodology of education, e.g. the specialised knowledge of the physicist may be required to provide information on the selection of suitable content for a school science course. To these contributions must be added those gained independently through research in methodology of education itself.

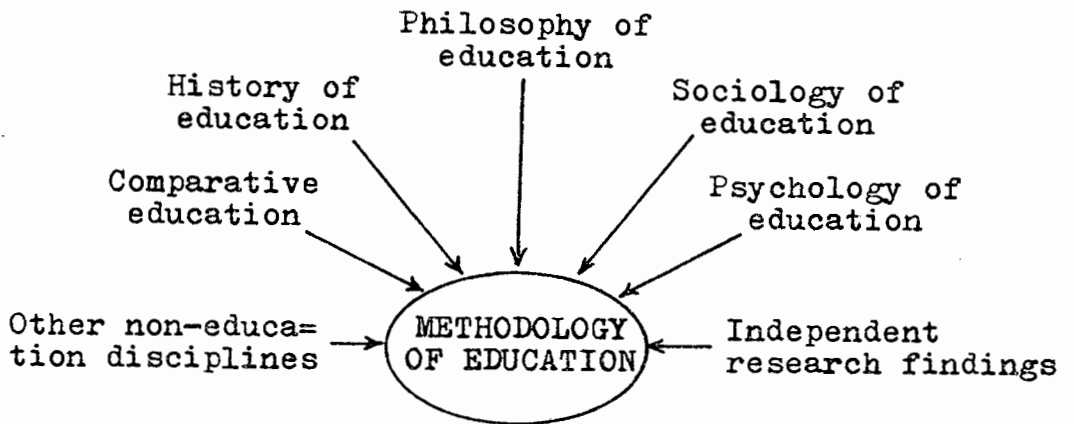


Fig. 2.3 Methodology of education draws on a number of other part-disciplines as well as on its own research

In drawing upon the other disciplines from outside the realm of Education, it should be remembered that methodology of education is concerned with teaching in its educational context. Teaching or training in a non-educational setting, e.g. for

the acquisition of useless knowledge such as the memorisation of the numbers of all the Browns in the telephone directory, is excluded. Similarly, the data collected from the training of pigeons to peck buttons acting on certain stimuli, cannot be directly applied or even extrapolated to the educational situation of the classroom.

2.2.3 The scope of methodology of education

2.2.3.1 Introductory

Being involved in so many aspects of the teaching situation, ranging from the people involved to the means of instruction, methodology of education has a very wide scope. For the present purpose only the major structures of this part-discipline need to be outlined.

An analysis of the present field of methodology of education yields a basic structure comprising three major components. These are

- (a) WHY the child should be taught, i.e. the aims and objectives of teaching in relation to the educational aims;
- (b) WHAT the child should be taught, i.e. the content of the teaching at different levels of development and for various purposes;
- (c) HOW the child should be taught, i.e. the methodological principles of teaching.

The task of methodology of education is to find answers of universal and general validity to these questions.

2.2.3.2 The aims and objectives of teaching

The aims and objectives of teaching can be compared to rungs on an education ladder, leading eventually towards the attainment of the general aims and ultimate goal of education. Although teaching aims and instructional objectives may appear to be very specific in nature, they should, both in their sequence and totality, contribute to the attainment of the general aims of education.

This condition is imposed on teaching aims and objectives since teaching cannot be educational without this condition. It

therefore follows that the aims of teaching do not refer to the isolated lesson only, but form part of a hierarchy that ranges from immediate instructional objectives, through aims set for a unit, a curriculum, a course, the school, etc., to the general aims of education and its ultimate goal. This hierarchy is presented in a simplified form in Figure 2.4.

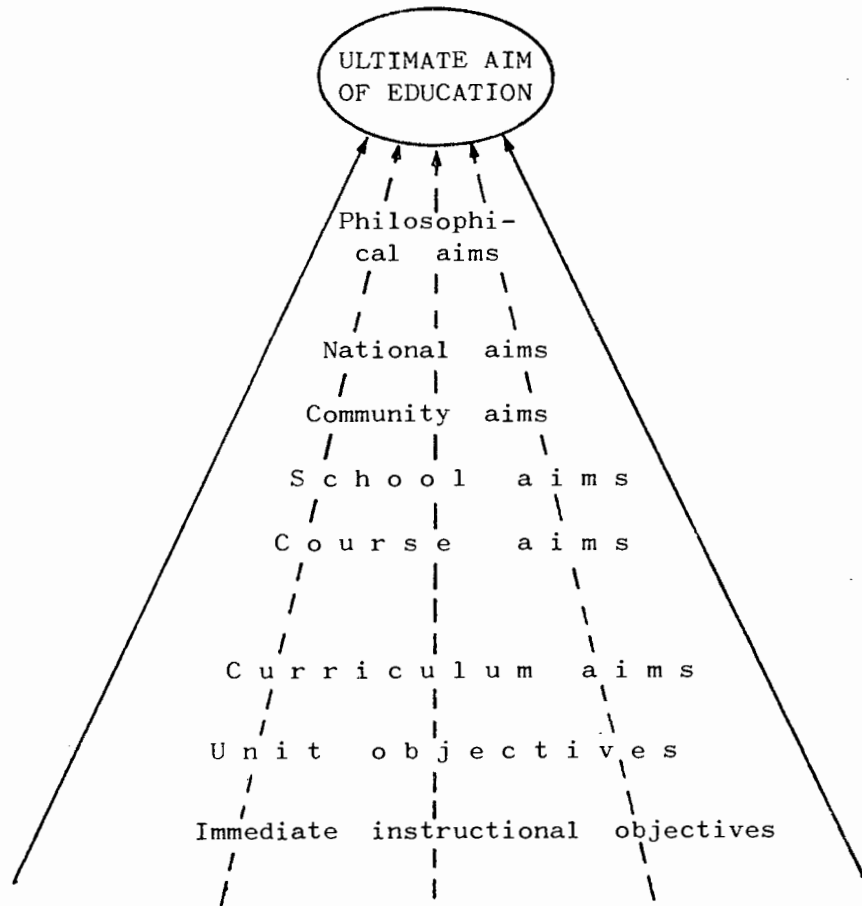


Fig. 2.4 The hierarchy of aims and objectives

It will be realised that as a result of this structure methodology of education finds itself in a dilemma: the aims of teaching cannot deviate from the ultimate goal(s) of education as formulated by the philosophy of education, and these goals, as is well known, are often influenced by creeds, dogmas and political ideals in order to serve their own, and sometimes questionable, purposes.

At the very outset, then, it is possible, and indeed very probable, that a subjective factor may be introduced into that aspect of methodology of education which deals with the aims and objectives of teaching. The methodologist of education must be aware of, and be on the guard against, such "contamination" of educational goals.

2.2.3.3 The content of teaching

In endeavouring to answer the question of WHAT the child should be taught, the methodologist of education has to make decisions not only on what subjects and activities to include in the programme of the school, but also on what content should be selected for inclusion in the curriculum for a particular subject or activity.

Both these decisions should ideally be guided by the aims of education, that is, the content serves as one of the mediums employed in the education of the child. A curriculum theory, as one of the theoretic structures of methodology of education, should provide suitable criteria for the selection of content.

Furthermore, in the framework of institutionalised education such as the school, the content provides the main area, the common arena, where teacher (educator) and child (educand) meet and interact. Together content, teacher and child constitute a three-fold area of interaction:



The three components of this triangle form a dynamic relationship which is present in any directed, purposeful educational situation. Being dynamic, this relationship is easily distorted by the over-emphasis of any one of its three components, and this may lead to an educational situation which may be either too child-centred, or mainly concerned with the mastery of subject matter, or so teacher-centred that it becomes completely authoritarian.

One other aspect of content should be mentioned at this stage, namely that of arrangement, sequence or organization. In addition to selecting the content and teaching it with the proper, balanced emphasis, the content needs to be arranged and sequenced in the proper order to suit both the development of the child and the nature of the subject or activity itself. This aspect is usually referred to as the organization of content.

Curriculum theory should also provide for valid criteria to serve as the basis for organization of content.

2.2.3.4 The methodological principles of teaching

Ideally the purpose of the school should be to direct its activities towards the attainment of the primary aim(s) of education. In order to reach this, teaching proceeds via the secondary educational aims, teaching aims and instructional objectives. These specific objectives and more general aims can only be achieved through effective teaching. Failure in the attainment of the secondary aims and objectives means failure in achieving the goals of the school as an educational institution.

It is reasonable to expect that an analysis of effective teaching - that is teaching which attains the objectives and aims specified for it - ought to reveal some common, generally applicable and valid principles. However, it is not self-evident that such principles will be found. It is part of the task of the methodologist of education to embark on such an analysis and to formulate the principles which may emerge. Curriculum theory should in turn apply these principles when developing criteria for the design of activities.

3. CURRICULUM STUDY AS AN ASPECT OF METHODOLOGY OF EDUCATION

3.1 Introductory

Relatively few major research projects and publications in the area of curriculum studies date from the era before World War II. In most of these publications the term "curriculum" very often has a different meaning to that generally used today. The advent of the post-Sputnik science curricula did not only lead to a new look at the curricula of the other school subjects, but also triggered a new interest in research and publications devoted to the school curriculum. The main impetus for this new wave of interest came from the publications of Tyler¹⁴ in 1950 and Taba¹⁵ in 1962. Since then curriculum studies have grown into a separate field of educational study and research. Departments of Curriculum Studies have been created in faculties of education and in many centres separate curriculum research institutions have been founded.

One of the results of these developments - especially in the Anglo-American approaches - was that curriculum theory tended to become divorced from the sub-discipline it really belongs to, namely methodology of education. Instead much attention was given to the results of psychology, sociology and cultural anthropology. It is even possible to find faculties of education with curriculum departments but no department of methodology of education. Many of the inherent weaknesses and disappointing outcomes of some of the modern curriculum developments may well be the result of operating outside the field of methodology of education.

3.2 The place of curriculum studies in methodology of education

That the study of curriculum development and design belongs to the field of methodology of education is obvious from the common elements revealed in their descriptions as given in paragraphs 1.2.11 and 2.2.2.2: both are involved in the WHY, WHAT and HOW of teaching. But whereas methodology of education is concerned with answering these questions in order to derive a general theoretical basis and to formulate universally applicable principles for teaching in its educational context, curriculum theory is concerned with answering them for the purpose of providing a "programme of activities or learning experiences"¹⁶ - a plan for teaching. Methodology of education is the theoretical science; curriculum study is an applied aspect of this science.

In making the latter statement it is not implied that curriculum study is limited to the application of methodological principles and that no separate, general curriculum theory can or should be devised. Certain conditions are, however, imposed: a curriculum theory should be derived from the principles laid down by methodology of education and should conform to, be in agreement with, the theoretical structures erected by methodology of education. Curriculum study derives its perspectives from methodology of education.

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CHAPTER 3

APPROACHES TO CURRICULUM DESIGN AND DEVELOPMENT

For the last twenty years there has been no lack of good suggestions as to how curriculum should be constructed

- Torstein Harbo¹

1. INTRODUCTION

1.1 The profusion of curriculum projects in science

The emergence of the Physical Science Study Committee (PSSC) from the portals of the Massachusetts Institute of Technology in 1956, marks the start of an ever-increasing volume of curriculum projects in the natural sciences. The PSSC Physics course² was followed by the Chemical Bond Approach (CBA)³ which was initiated in 1957 at a meeting held at Reed College in Portland, Oregon, and by the Chemical Education Material Study (CHEM Study)⁴, the origin of which can be traced to the work of a committee chaired by Alfred B. Garret of the Ohio State University, Columbus, in 1960. In 1970 a "humanistic approach" to the teaching of physics saw the light in the publication of the Project Physics Course⁵, although the initial work on this project had started as early as 1962.

A parallel development took place in Great Britain when, in December 1961, the trustees of the Nuffield Foundation set aside an initial £250 000 to develop new science curricula for schools in Britain. The original intention of the Nuffield Science Project⁶ was the preparation of curricula in physics, chemistry and biology for pupils of the age range 11 to 16. To these have since been added curricula for primary science, junior secondary science, physical science and programmes for sixth forms (Advanced Level).

These pioneering projects, which may be called major curriculum projects, published a variety of materials, including textbooks, teachers' guides, laboratory manuals, enrichment units, supplementary readers, ciné and loop films, apparatus and other

materials. Mainly because of the commercially available printed materials, these approaches were reasonably effectively disseminated and had a wide impact, even outside the boundaries of the English-speaking world. This influence is typified by the way the physics course, developed by the Department of Science Teaching at the Weizmann Institute of Science, Rehovot, Israel, got off the ground:

The "new spirit" of high school physics teaching reached Israel in 1961, when a few schools adopted a Hebrew translation of the American PSSC course. The first serious effort of reforming physics teaching in Israel started two years later, at the end of 1963, when the late Professor Amos de-Shalit, an outstanding nuclear physicist, assembled a study group of teachers and scientists ... It was decided that an entirely new course, including a new curriculum, textbooks, teachers guide, and laboratory equipment will have to be developed, borrowing, whenever possible, ideas from PSSC as well as from the other existing modern courses.⁷

Other projects in this category are, *inter alia*, the Australian Science Education Project (ASEP)⁸, the New Zealand Secondary Schools Curriculum⁹, the University of the Philippines Science Education Centre High School Physics Course¹⁰, the Physics Teaching Project of Brazil (PEF)¹¹, the IPN Curricula developed by the Institut für die Pädagogik der Naturwissenschaften (IPN) at the Christian Albrechts University of Kiel, West Germany¹² and the Projekt Leerpakketontwikkeling Natuurkunde (PLON), University of Utrecht, the Netherlands¹³. In a survey¹⁴ conducted to gather information about the various physics projects "almost every project director acknowledged the influence of PSSC and the Nuffield Physics Project on the design of project goals and procedures. Several also mentioned Project Physics ..."

In addition to these national curriculum projects, a very large number of smaller and specialised projects followed in the wake of the major curricula. A list compiled by the British

Council¹⁵ contains information on 27 projects devoted to general and integrated science, 7 projects for the physical sciences (physics, chemistry, physical science), 9 life-science projects and 4 projects for technical science subjects, for the United Kingdom alone.

Even if allowances are made for the right of existence of smaller projects designed to provide for specific and specialised needs, this proliferation of curricula, covering essentially the same content in the field of school physics and chemistry, indicates dissatisfaction among scientists and teachers with the materials produced by the major curriculum projects. This is borne out by the case studies of approximately 100 curriculum development projects, carried out by A.A. Strassenburg:¹⁶

Most ongoing projects were initiated by college and university science faculties. The next common prime movers were groups of science teachers in the schools. In isolated cases, projects were conceived and launched by university administrators, a professional teachers' association and a State Board of Education. Most respondents described as the primary motivating factor a sense of dissatisfaction with the science materials available

1.2 The theoretical models for the new curricula

The question arises whether all these different approaches do indeed represent different curriculum models, based and conceived on justifiable educational principles, or whether they are simply designed by curriculum developers with "gleams in their eyes".¹⁷

Rochford¹⁸ identifies 13 different "approaches" or "types of curriculum design", namely,

1. the conceptual schemes approach;
2. the technological-applied science approach;
3. the process approach;

4. the topic approach;
5. the thematic approach;
6. the project approach;
7. the approach based on the interests and needs of the learners;
8. the patterns approach;
9. the environmental approach;
10. the case histories approach;
11. the functional approach;
12. the objectives approach;
13. the problems approach.

Although each one of these categories, or combinations of them, can be identified in the variety of curriculum materials available, it is very difficult to discern or extract any new or original insights or models of curriculum design. There is very little internal evidence that the new projects were planned or developed according to "an optimal or even rational procedure".¹⁹ More than a suspicion remains that many of the latter-day curriculum projects are the result of what has been called "curriculum mongering" or "educational bandwaggoning".²⁹

In order to determine what this multitude of curricula has to offer in terms of an "approach" or model for curriculum design, one has to turn to the results of critical analyses and evaluations. In this area the available information is meagre and disappointing. Articles published under titles such as "The CHEM Study Course - An Objective Appraisal"²¹ or "BSCS - An Analysis of the New Biology Curriculum"²² turn out to be no more than the subjective opinions of teachers involved in the teaching of these courses. Even texts devoted to the teaching of the sciences tend to accept these so-called evaluations uncritically and quote the results of these "evaluations" as valid assessments. The position is perhaps best summarised by Strassenburg:

In most cases the evaluations consisted of questionnaires completed by students and/or teachers. Only two of these evaluations had been conducted

by evaluators who were not regular project staff members. One tested for changes in student attitudes; three tested performance on science tests using controls of some kind; the remainder were little more than collections of opinions.²³

Torstein Harbo²⁴ arrives at a similar conclusion and states that "we come (sic) aware that the originality of most of the models is not nearly as great as it appears at first glance". According to him, the many attempts at curriculum design are unmasked as imitations of one and the same model in curriculum theory: "The model is not normally identified with a name by its standard bearers, because it is regarded as the model".

Harbo calls this model the "means-end model" or the "Tyler rationale" and states that it rests on the assumption that the pedagogical activity is first of all a goal-oriented activity. The first consideration is to decide on the aims and objectives, and then to choose the relevant means for achieving these objectives. According to Harbo an analysis of the majority of the existing science curricula shows them to be structured on this approach.

He identifies two exceptions among the modern curricula, viz. "Science - A Process Approach" and the "IPN Curriculum Physik". In these curricula he discerns that the subject matter and the different kinds of pupil activities are more important than the specified objectives set up for each lesson. He names this model the "Begegnung" model, using the term in the broad sense that it is used in the publications of Weniger and Roth. He suggests the term "encounter model" as a suitable English translation. The encounter model, according to Harbo, also includes statements of aims, but these serve to provide direction rather than a terminal point to be achieved.

Buttle²⁵ essentially agrees with Harbo's identification of two major models for curriculum design, calling them the "input-output" model and the "open" model, respectively. Of the first he says:

... education is viewed on this model as a system having a set of inputs which are subjected to various processes in order to yield corresponding outputs ...²⁶

He also agrees that this model occupies the central position in the large-scale curriculum projects.

The "open" model he describes as being essentially learner-centred. Learning arises out of the dissonance between the new situation the pupil is confronted with (Harbo's encounter?) and his existing cognitive schema. "Expressed simplistically, the emphasis is upon process .."²⁷

The analysis by the author of a variety of science curricula from a number of countries²⁸ revealed no essentially different models to those identified by Harbo and Buttle. Although some of the curricula analysed claim to be based on specific theories, e.g. the Schools Council Integrated Science Project (SCISP) based on Gagné's learning hierarchy²⁹ or the Science 5/13 project based on Piaget's stages of development³⁰, these theories seem to serve mainly as bases for determining the type or "domain" of the objectives selected for these projects and of the teaching methods used.

The curriculum models designated by the terms "means-end" and "input-output", are characterised by the formulation of objectives to be attained through the learning experiences designed or suggested for the curriculum. Often, but not always, these objectives are of the behavioural type, i.e., the objectives describe certain changes in pupil behaviour to be achieved. Because of the central place occupied by objectives in this model, the term objectives model will be used for the purposes of this discussion. For the other approach, Harbo's term, encounter model, is preferred.

2. CURRICULUM MODELS

2.1 A brief review

Curriculum theory, as a specialised field of study, can be traced to Franklin Bobbitt's publication, The Curriculum, in 1918.³¹ According to Bobbitt "the central theory is simple. Human life, however varied, consists in its performance of specific activities. Education that prepares for life is one that prepares definitely and adequately for these specific activities".³² According to Bobbitt these activities, however diverse they may be, can be discovered, and that from them can be found out what abilities, habits, appreciations and forms of knowledge are required. These, then, form the objectives of the curriculum. Already, with Bobbitt, one finds a special preoccupation with the question of how educational objectives should be formulated.

In the United States of America the "objectives type" curriculum more or less held its own until the late 1920's and early 1930's. At this stage the ideas of the pragmatist, John Dewey³³, started to penetrate the classroom. The curriculum ideas of the pragmatists are summarised by Michaelis et. al.³⁴ as follows:

... the ideas of Dewey particularly influenced refinement of educational procedures. Childhood was recognised as a period distinct from later development, with concerns, interests, and developmental needs not necessarily related to preparation for adult life. These interests and needs were to be met through appropriate learning experiences. This led to the development of the "project method" of Kilpatrick, and to the unit plan, in which topics of interest to children became the centre of organisation of learning experiences ... In some programs, all subject areas were related through a core curriculum. Often this meant that topics such as ... (e.g.) ... the harbor, with language, mathematics, and science learnings developed in terms of application to study of the core topic.

To Dewey and Kilpatrick the objectives-attainment procedure is not fundamental to the educational activity. It plays a secondary role; the primary thing is the activity. The activity curriculum, with its emphasis on social relevance of content, activity methods and pupil interest, is essentially a variant of the "encounter model". It advocates the "scientific method" as mode of enquiry.

Reinforced by the 'heuristic method' advocated by Armstrong³⁵ at the turn of the century, the activity curriculum model held sway in the United States and to some extent in Great Britain, as well as in their spheres of influence, up to the mid-1950's. Its influence was especially marked in the fields of primary and junior secondary education and led to the creation of subjects such as "general science" and "integrated science".

From approximately 1955 the "objectives model" or "rational curriculum construction" returned to favour, especially in the area of senior secondary science education. This could have been the result of the influence of Tyler, Taba and other curriculum writers, or, perhaps more likely, because of the direct participation of subject specialists such as physicists and chemists, in the design of new curricula. The impact of these curricula on science education elsewhere in the world, has already been pointed out.

Most of the major curriculum projects, with the possible exception of the Project Physics Course, were not intended as courses for the whole of the secondary school population, but only for the more academic, science-oriented pupil. Estimates ranging from the top 10% to the top 25% of the high school population, were cited as the target populations for these curricula.

The "selective nature" of the major curricula was severely criticised by educationists and politicians, and very soon led to the development of programmes for pupils of average and low ability. The current political climate in the Western world, and the interpretation of democracy in education, perhaps best typified

by the education legislation of the British Labour Government, led to the dissolution of "selective" academic schools and to a changed interpretation of the idea of comprehensive schools in terms of "mixed ability teaching" rather than of a comprehensive range of subject choices. Similar movements can be discerned in other countries, e.g. forced racial integration by means of "bussing" in the United States and social integration by means of comprehensive schools on the European continent.

In this process of providing curricula for mixed ability groups, the very fabric of school science as a reflection of the various, accepted subject divisions or disciplines (physics, chemistry, biology) was torn to shreds. Educationists began to question seriously the teaching of science "for the sake of science" and the movement for "education through science" gained rapid impetus. At present such issues as the social and environmental implications of science feature prominently in these curricula, and expressions such as "attitudes", "awareness of" and "sensitivity to" have replaced the knowledge and skills objectives in the preambles to the programmes. In these curricula the trend again is to use activity - a feature of the encounter model - as a basis of construction. Work sheets, games and simulations form the backbone of the instructional method.

The German-Dutch curriculum movement, as an example of the developments in Europe, took a course somewhat different from the Anglo-American.

By the end of the 1920's the German movement was already in its final phase - a phase marked by searching reflection and self-criticism... As regards curriculum theory this self-criticism meant a break-away from both the technological means-end model and the glorification of the spontaneous activity of the pupil.³⁶

Thus rejecting the rigid objectives model as well as the free activity model of Dewey and Kilpatrick, the curriculum is reconstructed as an encounter - designed, structured and directed by the teacher - between the pupil and a sample of the culture.

The encounter model held its own in Germany up to the mid-1950's. Since then the objectives model has been applied in the construction of science curricula in most of the different states (Länder) comprising the German Federal Republic. Remarkable is the great influence of behavioural-type objectives in the design of curricula for senior high school physics and chemistry.³⁷

The present state of development of curriculum models is difficult to evaluate. Interviews with curriculum developers from more than 20 different countries³⁸ reveal not only a lack of knowledge of theoretical models, but very few see the need for such models in curriculum construction. What is revealed, however, is a variety of motives and reasons for curriculum development. This, too, will be taken up in this discussion.

The trends in curriculum development for the sciences in South Africa similarly yield no underlying curriculum model or rationale. The different syllabuses, as summarised by Fox³⁹ and analysed by research students⁴⁰, indicate the influences of overseas approaches rather than curricula structured on overseas models for curriculum design. These influences are apparent from the creation of the subject General Science in the 1950's, the marked influence of the ideas of the Nuffield Science Project on later revisions of the syllabus for General Science, and the inclusion of material from PSSC, CBA and CHEM Study in the syllabuses for Physical Science Higher Grade and Standard Grade. These influences are readily identifiable in the syllabus content, the prescribed experiments, apparatus supplied by the various educational authorities (Departments of Education) as well as in the textbooks produced for these syllabuses.

2.2 The objectives model for curriculum design

2.2.1 The Tyler Rationale

Building on the pioneering work of Franklin Bobbitt, the Americans R.W. Tyler and V. Herrick⁴¹ developed the foundations of the objectives model for curriculum design. The rationale for this model is clearly stated by Tyler in his Basic Principles

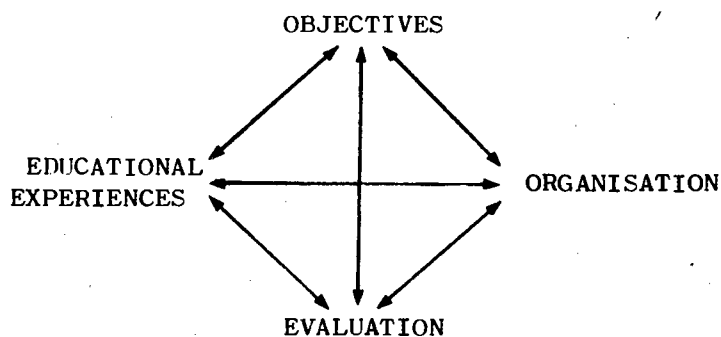
of Curriculum and Instruction, 1950:

1. What educational purpose should the school seek to attain?
2. What educational experiences can be provided that are likely to attain these purposes?
3. How can these educational experiences be effectively organised?
4. How can we determine whether these purposes are being attained?⁴²

From these four questions the elements of the curriculum model are derived, viz.

1. objectives;
2. educational experiences (content + method);
3. organisation;
4. evaluation.

Each of these elements is related to the others and decisions regarding any of them are dependent on decisions made about the others. Similarly, changes made to one element may affect all the others. Although there are variations in the terminology employed⁴³, these elements and their interrelationships are usually represented by a diagram such as the following:



Tyler himself assigned a dominant role to objectives. They are, he states,

criteria by which materials are selected, content is outlined, instructional procedures are developed and tests and examinations are prepared.⁴⁴

This has led to the interpretation of a curriculum model with a fixed starting point:

It is first a question of deciding purposes, stating objectives. Secondly of selecting and organising the experiences necessary to attain these purposes. And finally of evaluating in relation to the starting point.⁴⁵

As so often happens, this interpretation is not that which was intended by original designers. Herrick and Tyler⁴⁶, for example, suggest that curriculum design becomes more effective in improving an educational programme if its major focus is on problems of selecting and organising the teaching-learning experiences of pupils.

2.2.2 Further development of the objectives model

Various refinements of the objectives model have been suggested by different educationists and authors, such as Taba (1962), Maccia (1965), Lamm (1966), Taylor (1967) and Nicholls and Nicholls (1972). The basic structures of these models of curriculum design will be outlined here, but the rationales and arguments used in their design and development will receive attention in Chapter 4.

2.2.2.1 The Taba model⁴⁷

Of her model, Taba says that it "makes it possible to have a common curriculum pattern without necessitating a uniform curriculum". The schematic model of a curriculum design attempts to organise the chief points at which curriculum decisions are made, the considerations that apply to each, the relationships that should exist among these points, and the criteria. In a footnote she explains that this scheme is an extension of the one presented by Herrick and Tyler in 1950.

A MODEL FOR CURRICULUM DESIGN

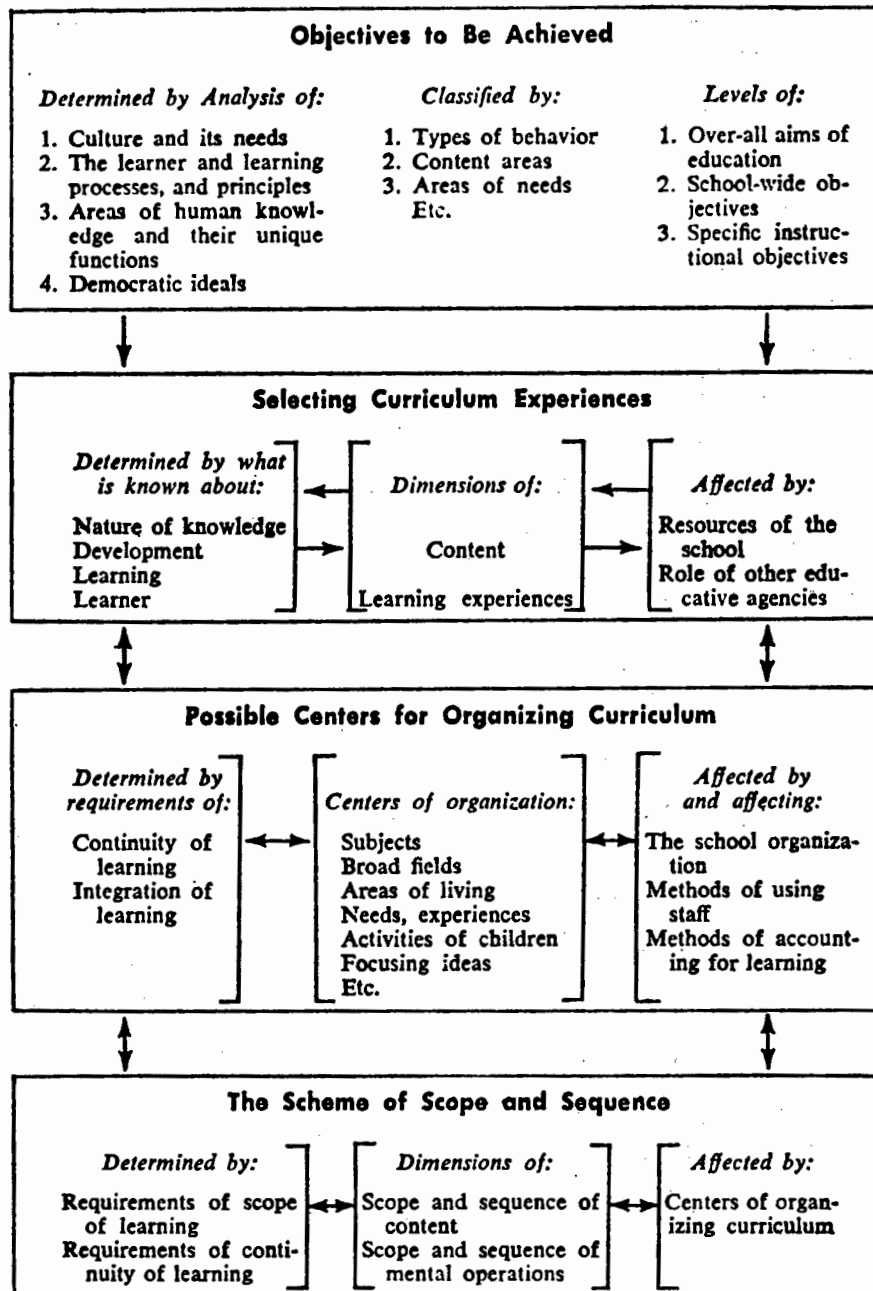


Fig. 3.1 Taba's model for curriculum design

2.2.2.2 The Maccia model⁴⁸

The theory proposed by Elizabeth Maccia of the Ohio Educational Theory Centre, is an example of a deductive approach to the building of a curriculum model. She identifies four kinds of theory, namely event theory (or reality theory), form(al) theory, valuation theory and praxiological theory. Each kind of theory is in turn used to derive the sub-theory of the curriculum.

Formal curriculum theory gives meaning to the form of the main themes of a discipline;

curriculum event theory erects propositions about the content of instruction;

valuational theory is concerned with curriculum objectives;

praxiological theory (theory about practices) is concerned with the appropriate means by which the curriculum objectives can be attained.

These four curriculum sub-theories are used to construct a curriculum theory model, as indicated by the following diagram:

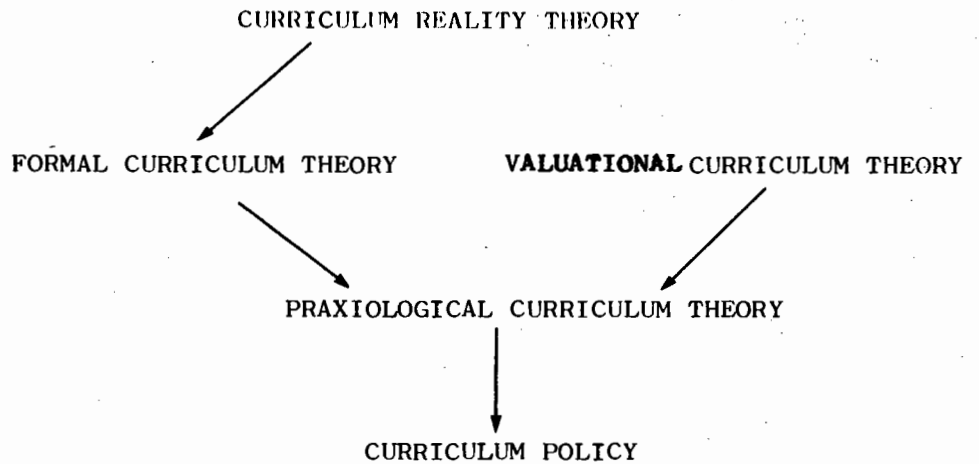


Fig. 3.2 Maccia's curriculum theory model

2.2.2.3 The Lamm model⁴⁹

Lamm sees the curriculum as the intersection of the area of the pupil, the teacher and culture. His model, which is shown diagrammatically below, rather suggests possible avenues of approach than a structure to serve as a guide for curriculum construction.

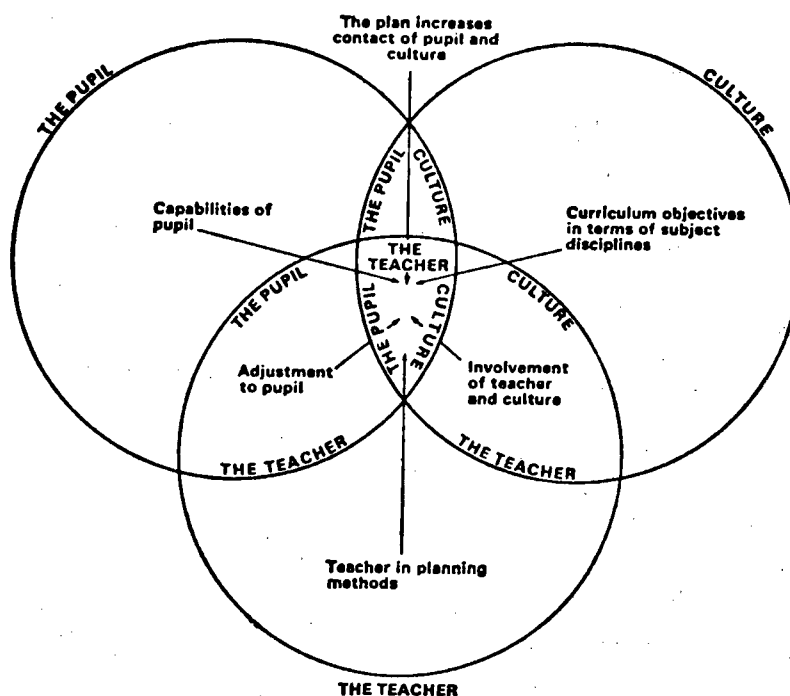


Fig. 3.3 The Lamm model of the curriculum

2.2.2.4 The Taylor model⁵⁰

Taylor states that the description of the curriculum as a bringing together of knowledge, methods and objectives may be more acceptable to the teacher than the learning experiences (encounter) model. His proposed model relates to the general theory suggested by Maccia in the sense that he is concerned with the curriculum event theory only. For this purpose he suggests a three-dimensional structure for the curriculum:

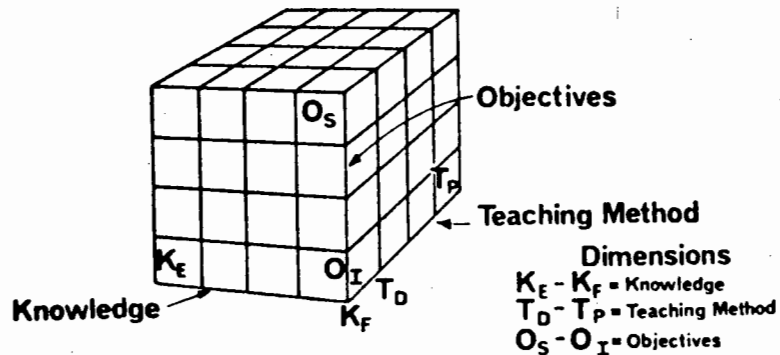


Fig. 3.4 Taylor's model for curriculum structure

The three axes of the cube represent, respectively, knowledge (K) ranging from knowledge of simple elements of experience (K_E) to formal knowledge (K_F), i.e. knowledge of the disciplines, including aesthetics and morals;

teaching methods (T) ranging from direct, or didactic teaching (T_D) to the point where the pupil is his own teacher (T_P);

objectives (O), ranging from intellectual objectives (O_I), such as the knowledge of specific facts and simple intellectual skills, e.g. reading, to self-knowledge (O_S).

According to him this model indicates clearly the depth, breadth and balance of a curriculum, as may be illustrated by applying the model to the curriculum for the infant school:

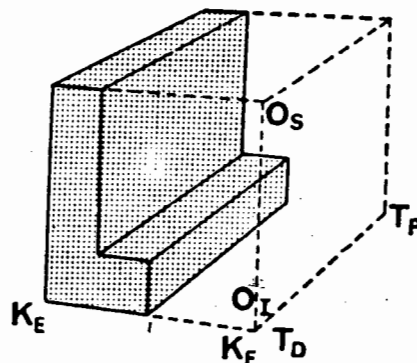


Fig. 3.5 Taylor's model applied to the infant school

Taylor also claims that this model can be used to distinguish between extrinsic motivation of the pupil, namely, that which is outside the cube, and intrinsic motivation, i.e. inside the cube.

2.2.2.5 The Nicholls model⁵¹

Audrey and S. Howard Nicholls retain the four basic elements of curriculum construction, viz. selection of objectives, selection and organisation of content, selection and organisation of method, and evaluation. To this they add diagnosis and argue for "a much wider and more comprehensive approach to diagnosis, an analysis of all the factors which make up the total situation ..". The diagnosis stage is added to their cyclic curriculum model, under the heading situation analysis:

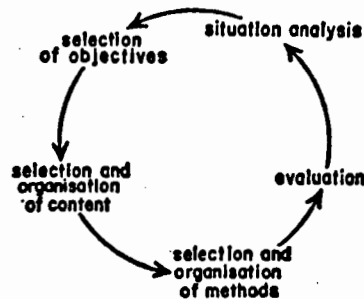


Fig. 3.6 The Nicholls model of curriculum development

They see the curriculum as a continuous process, subject to continuous feedback and change. "Such a concept of curriculum development implies that there is no one starting point and that it is a never-ending process".⁵²

2.2.3 The basic structure of objectives models

In spite of their differences in approach and terminology, and the different facets of curriculum illuminated by each of them, all these models contain one single, common, determining dimension, viz. the key role played by educational objectives.

These objectives not only determine the selection of content and

method and the way they should be organised, but the success of the curriculum is also evaluated in terms of the attainment of these objectives.

The different objective models, as well as other information on sources for objectives, taxonomies for educational objectives, the nature of knowledge, criteria for selection, and other relevant data, have been combined by Kerr⁵³ into a "model for curriculum theory". This model provides a representative picture of the present status of the objectives approach to curriculum design.

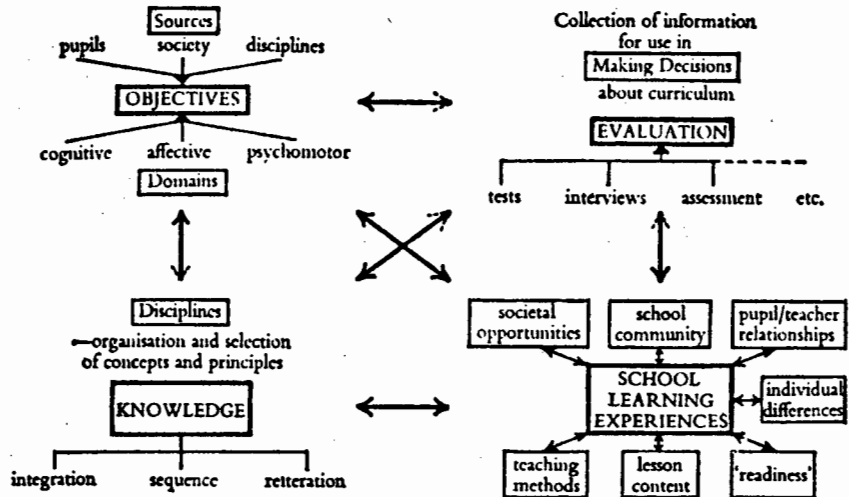


Fig. 3.7 Kerr's model for curriculum theory

The application of this model in the process of curriculum design may be illustrated as follows:

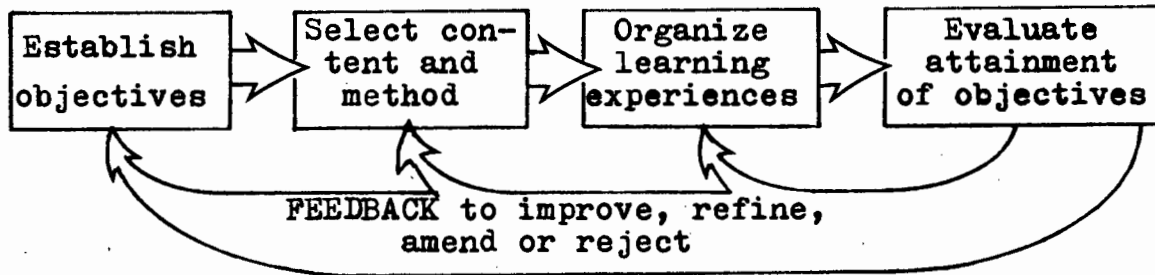


Fig. 3.8 The application of the objectives model

2.3 The encounter model for curriculum design

2.3.1 The Dewey rationale

Quite a number of authors on the encounter curriculum "go back to J. Dewey's contention: the primary thing is the activity".⁵⁴ In spite of some vitriolic criticism and rejection of Dewey's ideas⁵⁵, his approach to the school curriculum, reinforced by a renewed emphasis on heuristic methods and discovery learning by Bruner⁵⁶, still has a major influence on modern science curricula.

The educational ideas of Dewey and his followers, such as Kilpatrick, Bode, Childs and Counts, may be summarised as follows:

1. They reject any final educational aim or goal. Such a goal would be static, indicating some unchangeable state of perfection, and rigid, allowing no adaptation to changing circumstances. The basic characteristic of all life is growth, and this requires adaptation, i.e. a dynamic and active ability to change behaviours in order to meet new situations. In terms of the curriculum it means that

.. the educational process has no end beyond itself; it is its own end; and that the educational process is one of continual reorganizing, reconstructing,

transforming ... Since in reality there is nothing to which growth is relative save more growth, there is nothing to which education is subordinate save more education ..⁵⁷

2. The social criterion should be employed in the selection of content. "The end and standard of the school work is to be found in its functional relation to social life"⁵⁸, or, in the words of Dewey himself:

The curriculum must be planned with reference to placing essentials first, and refinements second. The things which are socially most fundamental, that is, which have to do with experiences in which the widest groups share, are the essentials. The things which present the needs of specialized groups and technical pursuits are secondary.⁵⁹

3. The curriculum should be experiential, i.e. an activity curriculum. Experience is seen as a process of activity and knowing is but one aspect of experience. Activity, experience and knowledge cannot be separated. Childs states:

Both the pragmatic theory of experience and the pragmatic pattern of reflective thought are involved in his conception of the experience or activity curriculum. The unit of that curriculum in experiential terms is an activity that begins in a disturbed or tensional situation and which eventually in a resolved or satisfying situation.⁶⁰

4. The curriculum should be child-centred, i.e. based on the natural abilities, needs, interests and activities of the child. Four such natural needs are identified, namely the need for social living, the creative need, the need for investigation and the need for artistic expression.
5. The method to be utilised is that of self-activity based on the principles of scientific method.

.. scientific method provides a working pattern of the way in which and the conditions under which experiences are used to lead ever onward and outward.

Adaptation of the method to individuals of varying degrees of maturity is a problem for the educator...⁶¹

6. The role of the teacher is that of leader and councillor; he is not the traditional master, but has a more indirect role of participating in activities and discussions, making suggestions and providing aid where required.

The educator's part in the enterprise of education is to furnish the environment which stimulates responses and directs the learner's course.⁶²

7. The subject areas included in the curriculum, chosen so as to provide a broad spectrum - a slice of life - should be socially relevant and not be narrowly specialised.

This implies the creation of subject areas not necessarily conforming to accepted ideas of disciplines. An education in general science is socially more meaningful than a study of, say, chemistry, physics, botany or zoology.

2.3.2 A general model for an encounter curriculum

Very few curricula based on the encounter model conform to all seven conditions of the Dewey school. The "IPN Curriculum Physik", mentioned earlier, contains, for instance, behavioural objectives; the Dutch PLON programme, is an activity-based encounter curriculum limited to a single discipline, physics. A general scheme for an encounter curriculum model would not differ very much from the following:

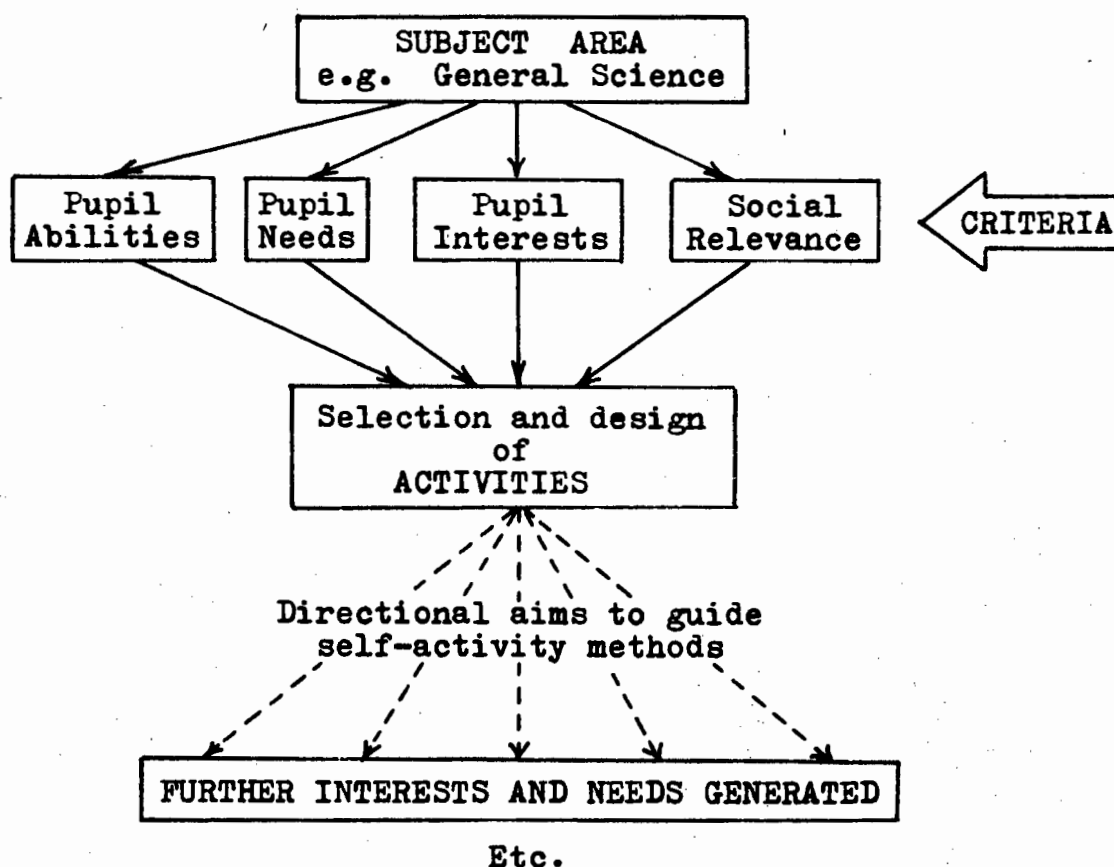


Fig. 3.9 A general scheme of the encounter model for curriculum design

A typical encounter curriculum for General Science, for example, would contain a number of activities or "activity areas". In order to meet the demands of, say, pupil interest, these activities are suggested rather than prescribed. They should allow for adaptation by the teacher for local circumstances, the composition of the class, the social environment, and so on. Although it is possible, and often fairly easy, to design laboratory activities suitable for fairly general application, such activities are often too narrow in scope to provide for the variety of interests and needs represented in any class group, and they are as a rule not suitable for successful integration across discipline boundaries. Thus laboratory activities are usually presented by means of work cards or work sheets which provide for different avenues of investigation and levels of attainment. An example of this approach can be found in the Scottish Integrated Science Course.⁶³

Another technique is that of the use of simulated real-life situations, or science games. A socially and economically relevant situation related to science education would be, for example, that of a small community dependent for its livelihood on employment in a chemical industry.⁶⁴ The effluent of this industry pollutes the river running through the community, causing unpleasant odours and conditions, also destroying some of the wildlife. The problem is presented to the pupils by means of a film or audio-slide programme. Decisions should be made about (1) alternative processes for production, which would require knowledge of the chemistry as well as of the economics of the different processes; (2) the effect on the community of closing down the factory; (3) possible methods and costs of treating or handling the effluent; etc. Pupils are given the opportunity to express opinions and discuss the problems involved from the point of view of the factory management, the shareholders, the employees and the environmentalists.

The design of such simulation activities is difficult and ^{they are} often very costly to produce. Even the most "progressive" curricula usually provide for the inclusion of only a limited number of such activities.

One final example should be mentioned, namely that of the excursion or field trip. In the context of the physical sciences these can be to a mine, a factory, workshops or any other suitable local resource of interest to the pupils. The following diagram indicates how the encounter from a visit to a fish pond can lead to a variety of activities which provide for the many interests of the different pupils.⁶⁵

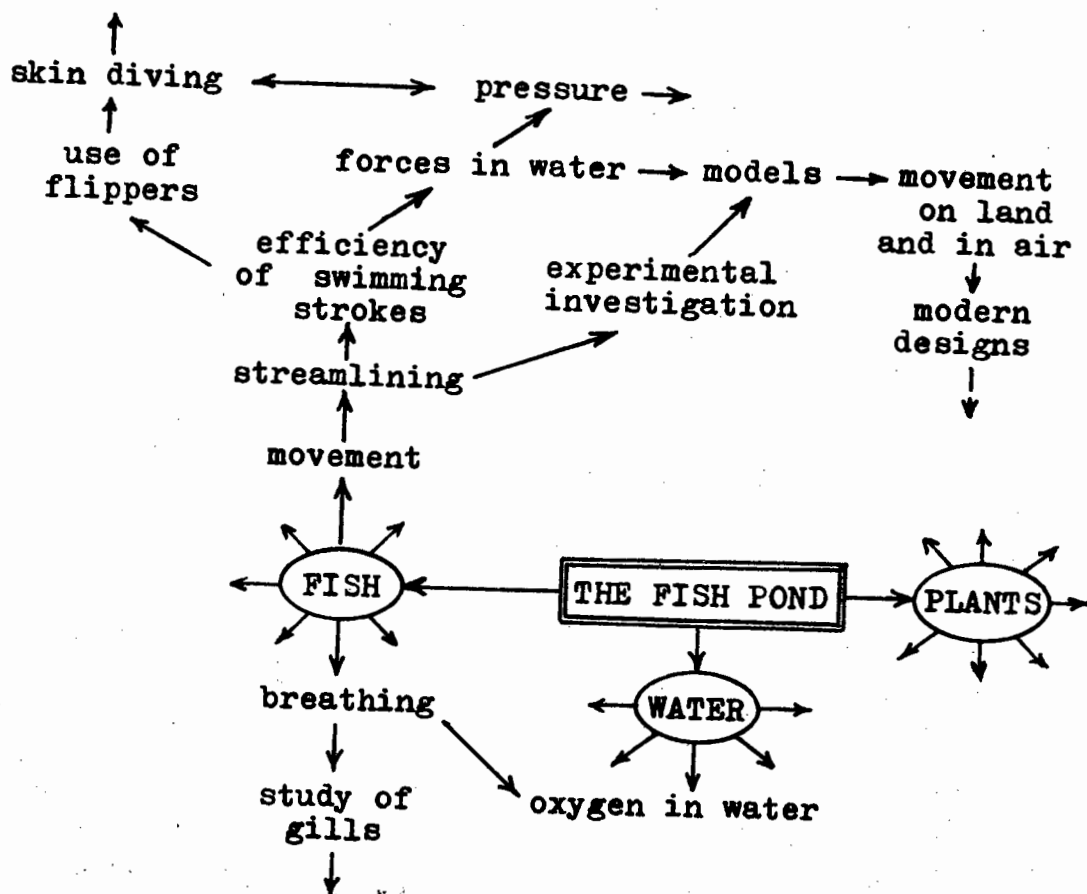


Fig. 3.10 A scheme illustrating how an encounter involving a visit to a fish pond may generate a variety of activities and experiences. Only a few possibilities are indicated.

It should be pointed out that the scrutiny of science curricula from a variety of countries reveals that the encounter curriculum model is used extensively for the design of courses for primary and junior secondary pupils, and to a lesser extent for the non-academic lower and middle ability groups of senior secondary classes. In courses for the academic, science oriented pupil, such as the British O- and A-level courses, the German Gymnasium-courses, the French Lycée-courses, and other similar or comparable curricula, the encounter model has to make way for the objectives model. The activity methods, such as optimum pupil participation, discovery methods and independent learning programmes are, however, very often incorporated in these curricula.

As a rule they are more structured and less open-ended than the elementary science courses.

3. THE MOTIVES AND PROCEDURES FOR CURRICULUM DESIGN

3.1 Motives behind the development and design of new curricula

3.1.1 The major curriculum projects

Although the Russian success in the satellite race is generally quoted as the spark that set off the curriculum explosion, this is not quite factual. PSSC, for example, got off the ground a year before Sputnik did. The Russian success did, however, lend impetus to the curriculum developments in science in the United States and might have been one of the major reasons for initiating most of the other major programmes in that country.

Perhaps the real reason for these curriculum changes stems from the re-establishment of international scientific communication after World War II and the realisation that many of the previously "esoteric" aspects of physics and chemistry, such as atomic and nuclear physics and quantum-mechanical explanations of chemical bonding, were not reserved for post-graduate studies anymore, but were actually practically applied in nuclear devices and semi-conductors. High school science became out-of-date, and in some areas, even obsolescent, overnight. The first people to realise this were obviously those who had direct contact with the products of high school science education - the universities. The major curriculum projects were therefore initiated by university scientists who also took a major part in the actual selection of content and design of materials.

3.1.2 The second phase of curriculum development

The second phase of curriculum development in the sciences can be divided into two categories, viz. (a) curricula developed for other countries and education systems as a consequence of the influence of the major curriculum projects, and (b) curricula developed in competition to the major projects to provide for "particular and specialised needs". In some cases these were valid needs, e.g. the Project Physics Course was designed to

provide a good physics course, based on an approach that would appeal to a wider audience of high school pupils, both academic and non-academic. Unfortunately this is not true of many of the other curricula. Strassenburg's publication of the results of case studies of a hundred science curriculum projects, summarises the position adequately.⁶⁶ The following conclusions are based mainly on this work as well as on interviews by the author of curriculum developers from more than 20 different countries.⁶⁷

3.1.2.1 The motivations of curriculum developers

A variety of reasons for developing new projects was offered by curriculum developers. The following conclusions, confirmed by the findings of Strassenburg, were drawn:

1. The majority of new projects were not initiated on the basis of evidence collected to show the existence of unmet needs or to identify specific, proven deficiencies in existing curricula.
2. Many projects were initiated as a result of the influence of outstanding individuals.
3. Study groups of science teachers, often meeting under the auspices of science teacher centres in the United Kingdom, produced curricula for their own Local Education Authority or even smaller areas.
4. Faculties of Education, or School Science Research Centres developed curriculum materials as part of their research or in order to try out materials based on particular theories of development and learning.

3.1.2.2 The evaluation of curriculum materials

Evaluation, in the case of the smaller projects, is often completely ignored. In those instances where evaluation had been attempted, this was usually limited to collecting the opinions of participating teachers and pupils. With the exception of some government sponsored projects, no evidence could be found of objective evaluation by persons not involved in the projects themselves.

3.1.2.3 The implementation and application of materials

In order to gain an impression as to the way teachers use the curriculum materials in actual classroom practice, the author visited a number of selected schools in England and Scotland. Wherever possible an effort was made to select schools which were involved in the original trials of the new materials, as well as schools which selected the materials independently only after they became available. It should also be pointed out that the number of schools was limited and that the impressions gained may be applicable only to the small sample used. The following impressions were, however, confirmed in interviews with teachers:

1. Materials developed, e.g. worksheets, and experiments especially selected or designed for the courses, are often adapted or replaced by others of the teachers' own design.
2. The application of the materials and activities depend to a large extent on the teachers' teaching styles and habits. The implementation is more successful in those cases where the suggested method suits existing teaching styles.
3. Teachers who were not involved in the development or trials of the materials tended to use the materials in a more flexible manner than the other group.
4. Teachers tend to utilise activity and discovery methods during the introductory phase of topics and revert to a more didactic style of teaching as the topic is developed. This is specially true for senior secondary courses.
5. In spite of the unique freedom enjoyed by teachers in Britain, the influence of Science Supervisors is apparent. It is not unusual to find all, or most, high schools in an area served by a particular supervisor using the same curriculum.

From these observations it will be clear that curriculum development requires more than the design and production of a course and course materials. The teachers involved in the implementation should be fully informed about the rationales, reasons

and criteria used in developing the curriculum, as well as be fully trained in the application of the materials. If this is not done effectively, the evaluation of the curriculum may reflect incidental outcomes completely divorced from the intended aims, content and design of the curriculum.

3.2 Procedures for curriculum design and development

From an analysis of the different steps employed by the various agencies in the design and development of science curricula, a number of common procedures emerge. Not all curriculum programmes utilise all the procedures.

1. Establishment of the need for curriculum change

Ideally this need should be based on the carefully collected evidence and feedback from the existing curricula in order to expose the specific areas of dissatisfaction and deficiency.

2. Examination of the purpose and function of the school subject in the course structure.

Before embarking on the development of any curriculum clarity should be obtained about questions such as the following: For which group of pupils is the curriculum intended? Is it a terminal course or should it prepare pupils for further studies in this, or related, subjects? etc.

3. Examination and preliminary formulation of the main objectives of the curriculum.

Clarity should be obtained about the main aims, whether they are prescriptive and behavioural (as in the case of the objectives curriculum) or merely procedural and evaluative (as in the case of the encounter curriculum). These aims should conform to specified criteria.

4. Selection of content.

The content selected, whether in the traditional sense of areas of knowledge or topics to be mastered, or in the sense of "learning activities", should conform to criteria based on all those factors derived from knowledge of the learner, the subject area and the teacher.

5. The selection and development of methods and materials for the effective implementation of the curriculum. This stage cannot be undertaken as an activity on its own but should be based on the principles of Methodology of Education.
6. Organization. Although this stage is listed separately it usually operates simultaneously with the design of the content-method stages. Here, too, the organization of the teaching activities should be evaluated against a set of criteria.
7. Trial, immediate feedback and revision. The majority of major projects include this stage. The procedures, however, may differ, varying from trial of the whole curriculum and feedback based on formal evaluation procedures, to trial of smaller units or sections as they are produced, and evaluation based on simple opinion questionnaires and direct observation.
8. Production and implementation of the revised curriculum. It has already been pointed out that effective implementation requires in-service enlight^{en}ment and training of the participating teachers.
9. Continuous evaluation and feedback in order to assess the suitability and effectiveness of the curriculum as well as to be able to revise and improve the curriculum in the light of new evidence and knowledge.

The analysis reveals one obvious, but not surprising, omission, namely a statement about the theoretical basis - the curriculum model - on which the design is based. To these 9 stages, then, should be added in position number one:

10. Selection of a suitable model for curriculum design.

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CHAPTER 4

A PROPOSED MODEL FOR CURRICULUM DESIGN

It is feasible, I think, to build up a model for the curriculum, that is, for 'all the learning which is planned and guided by the school ...'

- John F. Kerr¹

1. INTRODUCTION

1.1 The need for a model for curriculum design

1.1.1 The terms "model for" and "model of"

It has been argued in Chapter 2 (a) that Education as a science is still in a very early stage of development, and (b) that this development will take place in a cumulative manner, drawing from information gained through the sub-disciplines of Education. The same argument applies to the development of the sub-disciplines. Curriculum theory, as an aspect of methodology of education, will not for a long time be able to qualify as "a theory of curriculum", but can only tentatively suggest a theoretical model for curriculum construction. This point of view is shared by Kerr:²

Although we are not yet, manifestly, in a position to present an acceptable model of a curriculum theory, it is feasible, I think, to build up a model for the curriculum Such a model could encourage the development of sub-theories of the identified components of the curriculum and perhaps show the way towards a unified theory.

This terminology, viz. "model of" and "model for" was first used by Maccia³ who suggested that "model for" describes only theory-models to develop a unified theory.

1.1.2 The role of curriculum theory in curriculum design

In spite of approximately 50 years of "curriculum studies" in the United States of America, only a very simple model of the curriculum has emerged, a model containing the four basic elements of objectives, content, method and evaluation, or

variations of them. Much of the subsequent work has been devoted to the classification and formulation of objectives by workers such as Bloom, Krathwohl, Skinner and Mager.⁴ Others have been involved in the design of learning experiences, or methodology, based mainly on the different views of psychologists such as Bruner, Gagné and Ausubel.⁵ Gradually "discovery learning", so eloquently propagated by Bruner, came to be accepted as the method for science education, in spite of the lack of convincing supporting evidence.

It is, therefore, not surprising that no major American science curriculum is based on a particular "approach" or model for curriculum design. The National Science Teachers Association (NSTA) of the United States published a "Position Statement" on curriculum development in science in 1962. According to this statement

The National Science Teachers Association has devoted five years to examination of its beliefs about the science curriculum. Officers, the Board of Directors, Committees, and the members have moved carefully, step by step, toward the formulation of this Position Statement.⁶

The disappointing outcome of this five year stint of examination and cogitation is the production of six statements and some additional remarks on evaluation. These are that school science education

1. must start as early as kindergarten or first grade;
2. must be articulated from one level to the next through grade twelve, or higher;
3. must encompass a full range of the contemporary knowledge and ideas which scientists employ;
4. must result in understanding the nature of the scientific enterprise through direct student involvement in the process of scientific inquiry;
5. must involve the best that is known about child growth and development and the psychology of learning; and
6. must be supported by first-rate staff, facilities, and instructional materials.

With regard to evaluation the Association believes that this process should be closely tied to the stated objectives of a given curriculum. But goals should be stated independently of the problem of evaluation, and methods should then be sought to test the attainment of these goals.⁷

There is no mention of a model for curriculum development although the remarks on evaluation imply acceptance of the simple "objectives" approach. The statement declares that "The Association believes in multiple efforts in curriculum development and will encourage and assist efforts involving creative and diverse approaches by many groups and agencies".⁸

Turning to Great Britain, one finds a very similar state of affairs. It would be sufficient to quote Hooper's introduction to an article by Kerr in this regard:

Theory has not played an important part in any of the recent curriculum changes sponsored by the Schools Council and the Nuffield Foundation because a coherent theoretical framework for guiding curriculum design is lacking. A simple model of curriculum includes four components - objectives, knowledge, learning experiences and evaluation. The model does not give guidance as to choice of objectives, content, etc. To achieve this, some sort of curriculum theory is required.⁹

The European scene does not provide an essentially different picture. The "Begegnung" or encounter model developed by the phenomenological school, is expressed in such vague terms that it is very difficult to apply it to actual curriculum construction, and ^{it} includes assumptions and conclusions about the methodology that are as yet unproven. Taking the polarity of pupil and the educational environment as the original phenomenon of the school, this model describes "in a clear and concrete way the beginning of the educational process, but it does not dare to state the ending beforehand".¹⁰ It is, therefore, not surprising to find that the curricula for physics and chemistry which may lead to tertiary studies of these subjects, steer clear of this model and are structured on the basis of an objectives approach.

The present state of the field may thus be summarised as follows: (a) theoretical studies and research have not yet produced a unified theory or model for curriculum design; (b) none of the major curriculum projects have consciously used any of the existing alternative models suggested as their basis of curriculum construction. A model for curriculum design is essential in order to obtain clarity and guidance as to the selection and formulation of the different components or elements of the curriculum.

1.2 Approaches to the development of a model for curriculum design

According to Kerr¹¹ "two broad approaches to the building of curriculum theory, both in their infant stages, can be discerned". He calls these the "deductive" and "inductive" approaches respectively.

1.2.1 The deductive approach to curriculum theory

The deductive approach to structuring a curriculum model is built on theoretical formulations derived from other disciplines. Concepts are then substituted, hypotheses and laws are deduced in a logical manner and the results are tested against the observable data.

The curriculum theory developed by Maccia and her co-workers is an example of a theory devised by means of the deductive approach. The two main objections against this approach, which is outlined in Chapter 3, paragraph 2.2.2.2, are

- (a) that the model does not provide for the evaluation of the curriculum, and
- (b) that the methods of deductive logic do not apply to human activities which are value-directed.

1.2.2 The inductive approach to curriculum theory

According to this approach a synoptic view of the curriculum is synthetically constructed from the observable data. Postulates, which are often no more than assumptions, are formulated as the bases of curriculum development. From these, prescriptions for curriculum design and evaluation are then derived. Curriculum choices are guided by the prescriptions of this model.

This approach, which proceeds from the particular, observed data to the generalised curriculum structure, has two main weaknesses, namely

- (a) that without a conceptual background, or a theory, it is impossible to make a valid selection from the observed data, and
- (b) that it provides a "patchwork" model of curriculum theory without any unifying structure, and one which is not dynamic in nature.

2. THE REQUIREMENTS FOR A MODEL FOR CURRICULUM DESIGN

2.1 Requirements derived from educational literature

A theoretical model designed to aid the process of curriculum design, should meet a number of requirements. The obvious one is that of applicability, but one could reason that this requirement can be met simply by devising a model which is so simple and meagre in detail, that it may turn out to meet only this requirement. As a first approach one could turn to the existing literature to determine those requirements identified by workers in this field. According to Taba¹² a model for the curriculum should be able to provide the following:

1. It must identify the basic elements of the curriculum.
2. It should indicate the balance between the elements in order to prevent inappropriate emphasis. For this purpose it should have an adequate "theoretical rationale".
3. It should make clear what the bases of the selection and the emphases on the various elements are, as well as the sources from which these criteria are derived.
4. It should make clear how the various elements and the criteria or considerations connected with them are related to each other.
5. It should convey an idea of how it deals with the major issues of organisation: what centres are used for organising curriculum experiences, what the concept of scope is

and how to determine an adequate scope, what provisions are made for sequence of content and of learning experiences, and how to handle integration of knowledge.

Kerr¹³ states that "theory has not played an important part in bringing about curriculum change simply because a coherent theoretical framework capable of guiding curriculum design is lacking". He includes those aspects indicated by Taba and adds that

The pattern and interrelationships among the various disciplines might be clarified by a theory of the curriculum, and that the field trials of new programmes might be designed to conform to the requirements of rigorous operational research.

Stenhouse¹⁴ sets out certain minimum requirements for curriculum planning, empirical study and justification:

It should offer:

A. In planning:

1. Principles for the selection of content - what is to be learnt and taught.
2. Principles for the development of a teaching strategy - how it is to be learnt and taught.
3. Principles for the making of decisions about sequence.
4. Principles on which to diagnose the strengths and weaknesses of individual students and differentiate the general principles 1, 2 and 3 above, to meet individual cases.

B. In empirical study

1. Principles on which to study and evaluate the progress of students.
2. Principles on which to study and evaluate the progress of teachers.
3. Guidance as to the feasibility of implementing the curriculum in various school contexts, pupil

contexts, environments and peer-group situations.

4. Information about the variability of effects in differing contexts and on different pupils and an understanding of the causes of the variation.

C. In relation to justification:

A formulation of the intention or aim of the curriculum which is accessible to critical scrutiny.

Michaelis and his co-authors¹⁵ present what they call "a model for curriculum development" to

1. serve as a guide to the development and revision of the curriculum, and
2. serve as a guide for the review and analysis of the curriculum.

Hooper¹⁶ points out the requirement of unity in a curriculum model:

The important thing is that the four key curriculum questions (here he refers to the four elements of the curriculum model) cannot be answered sequentially as is so often assumed ... Effective curriculum design requires an iterative process, where each question is constantly being reprocessed in the light of answers to subsequent questions ... Much curriculum discussion is infertile because discussion of objectives is not permitted to be contaminated by discussion of means. Form and content are fundamentally inseparable even though we must attempt to separate them out for purposes of analysis.

Unity, too, is emphasised by Bruner¹⁷ when he states:

Content cannot be divorced from pedagogy. For it is the pedagogy that leads the child to treat content in critical ways that develop and express his skills and values ..

The European and South African followers of the phenomenological school of Education do not treat curriculum as a separate field of study in the sense that it is interpreted in Anglo-American educational circles. Each "element" of the curriculum is the topic of a separate analysis in terms of the phenomenon of education, and very often "criteria" or "principles" are derived or formulated for each element.

Aarts¹⁸ stresses the fact that the curriculum should be

een didactische verantwoording van de leerstof, teneinde in deze leerstof enige orde te brengen, opdat de eenheid van de leerstof uit de verschillende leervakken zoveel mogelijk tot uitdrukking komt.

This emphasis on, in our terminology, "viewing the content in the light of the principles of methodology of education" (didactische verantwoording), is also shared by Van der Stoep and Van der Stoep¹⁹ where they state that it is the task of "didactics" (methodology of education) to search for answers to questions of content (leerinhoud), the learning done by pupils and the problems of special methodology.

The extracts from current literature reveal that there is very little agreement on what requirements a model or theory for curriculum design should meet, and in some cases very little distinction is made between curriculum theory and curriculum itself.

2.2 The formulation of requirements for a model for curriculum design

The following requirements for a theoretical model for curriculum design, which are consistent with the approach put forward in Chapter 2, can be formulated:

1. It should be general and universal, that is, applicable to any educational system regardless of any philosophical, ideological, national, political or religious influence on, or basis of, such a system.

2. It should be consistent with the principles of methodology of education. Since curriculum study is viewed as a branch or subdivision of methodology of education, this requirement follows logically.
3. It should be able to identify the essential elements of curriculum as well as the relationships which exist and the interactions which operate among these elements.
4. It should provide universally valid criteria for the selection and application of the elements. These criteria should apply to the complete process of curriculum development, i.e. for design and evaluation.
5. It should provide for all levels of education (teaching in its educational context), ranging from pre-primary to tertiary education.

This list includes the requirements suggested in the literature, but adds the requirement of universality of application to different systems and levels of schooling.

3. THE ELEMENTS OF THE CURRICULUM

3.1 Introductory

Curriculum is a development of institutionalised education. From its early usage as "the curriculum of the school", which listed the subjects to be taught, its meaning expanded as educational institutions, such as schools, developed to meet the demands of the increasing complexities of life. Curriculum, then, is an invention of educators and educationists to aid them in the organisation and description of the task of education. A logical, and straightforward, approach to determine the elements of the curriculum would be to define curriculum in terms of those elements one would like to include. This was the case in the early usage of the term. However, since the term "curriculum" already has an established meaning in Education, one has to look at the generally accepted description of the term (definition) as well as at its implementation (practice) in order to identify the constituent elements.

3.2 Elements common to all curricula

All curricula contain certain common elements. Analysis shows that these are

- (a) an aim or aims;
- (b) subject matter;
- (c) assessment of the attainment of the aims and/or the mastery of the subject matter by the students.

These three elements are also included in the simplest form of curriculum - the traditional syllabus.

3.3 Elements implied by the modern definition of curriculum

As has been stated in paragraph 1.2.11, curriculum is not just a matter of prescribing content but also of stipulating how it should be handled. According to this approach it means that a curriculum should also be concerned with

- (a) the method or methods of teaching; and
- (b) the arrangement, sequence or organization of the content and methods.

In addition, it is generally accepted that not only the students should be assessed, but that the effectiveness of the curriculum elements themselves, or the curriculum as a whole, should be evaluated. A third element is thus added, viz.

- (c) complete evaluation.

Assessment of pupils' performance is included in the evaluation.

3.4 Elements formulated by educationists

In addition to the elements derived from practice and definition, educational authors have formulated other elements which, according to them, should form part of the curriculum. These are,

- (a) system analysis; and
- (b) learning experiences.

3.4.1 System analysis

This component is included in the curriculum by terms such as "diagnosis"²⁰, "situation analysis"²¹ or "system analysis"²². Nicholls and Nicholls explain this component as follows: Where the components - objectives, content, method and evaluation - are broken down in smaller steps,

one of diagnosis is sometimes included and this is usually diagnosis of pupils' attainment, strength and weaknesses. The viewpoint expressed ... argues for a much wider and more comprehensive approach to diagnosis, an analysis of all the factors which make up the total situation followed by the use of knowledge and insights derived from this analysis in curriculum planning. This viewpoint sees such an analysis as a major stage in the process of curriculum development ..²³

The term "system analysis" is usually used in the context that the curriculum can be viewed as a dynamic system having a set of inputs and outputs. As this system is dynamic and constantly changing, it should be continuously analysed in order to determine what change in input has to be made to obtain the required output.

This aspect of the curriculum operates mainly, but not exclusively, during the implementation of the curriculum and the diagnosis or analysis is the task of the teacher. Some of the factors which may influence the dynamic curriculum and require analysis by the teacher, are the teacher himself (self-analysis), the pupils, the environment, the school building and the "school climate".

3.4.2 Learning experiences

Content and method are often fused into a single component known by names such as "learning activities", "learning experiences", "learning opportunities", "educational encounters", and the like. Because of the close, inseparable interaction between content and method in the modern approach to curriculum development, the creation of a term to describe this relationship, can be justified on many grounds. A problem arises when the term "learning experience" is used by the psychologist in the sense of the

"total mental phenomena directly received at any time", and by the educationist as "a planned and controlled relationship between pupils, teacher, materials, equipment and the environment, in which it is hoped that the desired learning will take place".²⁴

The formulation of a suitable term and a clearer description of what this term actually describes, will be undertaken later in this chapter (paragraph 4.1). At this stage it would suffice to point out that "learning experiences", as used by curriculum experts, is perhaps not an element of the curriculum but rather an area of overlap of two or more of the elements. It thus describes an interaction between elements and not a new, discretely different element.

3.5 The selection and formulation of the elements of a curriculum

3.5.1 The essential components of a curriculum

Every curriculum, in spite of the denials of some proponents of the "free" encounter curriculum, contains some aim, whether it is formally stated or not. The very fact of the existence of the school and the effort of designing some form of curriculum for use in the school, implies a purpose or aim.

In the second place it is obvious that all teaching involves some kind of subject matter, content or material to be learnt, even though the formal designation of "subject" or "discipline" may be frowned upon by some educationists.

Thirdly, the effective teaching and presentation of the content to the learner in order to facilitate learning by the latter, require the design and application of a method or methods.

A fourth component that presents itself very clearly is that of arrangement, sequencing or organization. Depending on a variety of factors, ranging from the structure of the content itself to the development of the learner, both content and method need to be organized in order to derive the optimum benefit from the teaching.

Finally, then, there should be some way of judging the success of the pupils as well as that of the curriculum. For this purpose the curriculum must have evaluation as an essential component. Although this element is mentioned last, it does not follow that it comes at the end of a particular sequence of curriculum design.

For the proposed curriculum model five elements are thus identified, namely,

1. the aims of the curriculum;
2. the content;
3. the methodics;
4. the organisation;
5. the evaluation.

3.5.2 The aims of the curriculum

The terms goals, aims and objectives, are used in various contexts in works on the curriculum. Some authors use them as synonyms, but the general trend nowadays is to draw some kind of distinction between them. Unfortunately, there is as yet no generally accepted, clearly defined meaning ascribed to each term, and different authors apply different interpretations according to their particular approach to the curriculum. The problem is further compounded by the fact that these three English words are often translated in German, Dutch and Afrikaans with a single term. Before one can embark on a discussion of this element of the curriculum it will be necessary to clarify the exact meaning of these terms.

Michaelis et. al. state²⁵ that

Goals provide broad and general directions for education, whereas objectives serve as guides to instruction designed to attain major goals. Goals help to clarify priorities by keeping central aims of education in focus, aims that are related to what is believed to be of greatest value to children and youth in our society. Objectives help to set the direction in each area of the curriculum and in units of instruction within each area.

These authors obviously distinguish between aims, goals and objectives, implying a change in meaning from the general to the specific, from the ultimate, remote aim of education in general to the immediate instructional objective in the classroom.

Nicholls and Nicholls²⁶ define aim as a statement in general terms indicating what it is hoped will be achieved, while objective is a statement indicating what pupils should be able to do as a result of learning opportunities presented. They also state that objectives set for classroom activities should be consistent with the overall aims, again indicating some kind of hierarchy ranging from the specific, instructional objective to the more remote and general aim. In addition these authors distinguish between short-term and long-term objectives, and between specific and general objectives. Short-term objectives are those set for a lesson, e.g. knowledge of the symbols of the chemical elements, whereas long-term objectives require an extended period of teaching, e.g. a certain amount of knowledge and understanding of the chemistry of the halogens. Specific objectives are those which are specific to the subject being taught, such as those given above; general objectives are not related to any subject area.

Similar distinctions may be found in the majority of works on the curriculum of English and American origin. The phenomenological school of Education, as interpreted by Gunter, makes the following distinctions:

The phenomenon of education reveals that there are always three types of goals both in education and in teaching. There are, first of all, the proximate or immediate and specific aims, of which there are a large variety. Secondly, there are the remoter and wider, more inclusive aims of which there are also quite a number. Thirdly, there is the ultimate or total goal, which embraces and includes all valid proximate and remoter goals. This is the final, highest, all-embracing and all-inclusive goal at which all educational effort is ultimately aimed. Every proximate aim serves as a necessary step or means toward the achievement of a wider, remoter goal, the latter in turn

constituting an essential rung on the ladder or milestone on the way to the final goal. At school each lesson in every subject has both its proximate and its remoter aims, and, by achievement of these, aims at bringing the pupils a step nearer to the ultimate goal of their education.²⁷

As has been pointed out, the translation from the original Afrikaans does not provide for differentiation in the use of the words "aim" and "goal" (or even "objective" where this occurs), but the same hierarchy from the ultimate through the general to the specific, is revealed.

Summarising, then, the following levels for the formulation of goals, aims or objectives can be distinguished:

1. a single ultimate aim or goal of education which refers to education in general and is not limited to a subject area or a curriculum only;
2. the intermediate, more general aims of education which may refer to education in general as well as to the subject area or curriculum; and
3. instructional objectives, which refer to the actual educational and teaching process in the classroom.

In agreement with the current English educational literature the terms "objectives" and "instructional objectives" (onderrigdoelstellings) will be reserved for the latter. Both the terms "aim" and "goal" will be used in respect of the other two levels since redefinition of words having an established meaning in common usage may lead to confusion. Where appropriate and necessary, however, a distinction will be made by the use of the appropriate adjectives such as "ultimate", "intermediate" and "general". The word "aim" used without such a qualifying adjective, will be used as the generic term which includes all three levels of formulation.

A theory for curriculum design should concern itself with educational aims of all three types. Not only should a decision be made about the ultimate aim of education, but the intermediate aims should be formulated in terms of and consistent with this ultimate aim. Criteria should be provided for the formulation of the intermediate aims and instructional objectives.

3.5.3 The content of the curriculum

Some decades ago the content of the curriculum would simply have meant the subject matter to be taught. Except for a few, so-called, experimental or project schools, school curricula were simply discipline-based and the content a selection of material from the relevant subject area. Physical science, for instance, was essentially a combination of topics selected from physics and chemistry. The physics component would include "units" such as optics, magnetism, electricity, gas laws, calorimetry, and others, while the chemistry as a rule consisted of a preparation-and-properties approach. The emphasis in this "traditional" type of course was mainly on the learning and recall of scientific facts.

Currently content refers to the whole range of knowledge, skills, understanding, attitudes and values to be learned. Although the vast majority of curricula are still organised on a subject basis, there is an increasing tendency to regard the subject-matter merely as a vehicle for the development of intellectual abilities, skills, values and attitudes. Recently much attention has also been given to a study of the structure of science as a human activity in school science teaching.

According to Taba²⁸ decisions about the content require analysis of the characteristics of the knowledge represented by school subjects and of the characteristics of the learning process. This overlaps with the analysis she prescribes for the selection of objectives, indicating the close relationship and interaction between the components "aims" and "content". Different interpretations of the structure of knowledge may lead to a discipline-based curriculum such as would follow from Hirst's theory of knowledge²⁹, a curriculum based on integration of disciplines, derived from the theories supported by Kerr³⁰ and Pring³¹, or the complete extinction of all subject boundaries as implied by Holt.³²

Hooper³³ claims that "the argument about discipline-centred versus interdisciplinary curricula is as unresolved as the argument about the aims and content of secondary education ..."

Obviously the argument about the curriculum content cannot be resolved unless clarity about the aims has first been achieved. Only then can criteria for the selection of content be formulated.

3.5.4 The methodics

The purpose of the curriculum, as an aspect of methodology of education, is not to devise a new or special methodology but to apply those principles of methodology of education as well as the findings of a special methodology of the subject area involved, which will produce improved instruction and learning. This means that the ways, means, techniques and strategies selected for the teaching of particular areas or units of the curriculum should be selected and designed according to the principles formulated by methodology of education. In a science subject, like Physical Science, which has an experimental foundation, the selection, design and development of apparatus and laboratory materials and methods, should also be assessed against these principles.

In addition, the relationship between the content and method should be analysed and clarified. In science teaching in particular, the controversy of discovery and investigative methods versus more "standard" or "conventional" teaching methods, is still raging furiously. Much of this disagreement stems from the variety of learning theories. Ideally one of the primary considerations in selecting and devising teaching methods should be how the pupil learns, but, as Gagné correctly points out

... learning theory as it exists today is a highly inelegant and unfinished entity. Nevertheless, there do appear to be some fairly fundamental and stable principles which serve to tell us what learning is not, and to suggest the outlines of what it is like.³⁴

A curriculum theory should make use of the principles of methodology of education as well as of the results of investigations into the learning of pupils in the classroom situation and in its educational context. If such principles and results are not generally agreed upon or have not yet been collected and classified, it would also be the task of curriculum theorists to provide a preliminary set of methodological principles which conforms to the existing knowledge of the learner and the learning process.

3.5.5 The organization of the curriculum

Taba³⁵ points out that "A method of curriculum development which devotes a long time to the analysis of objectives and philosophy, and which then omits the organization of teaching units, usually results in guides on paper which do not function in classrooms". She suggests that content must be organized with a view to getting adequate scope, sequence and integration. This suggestion implies the application of these three criteria for organization of content.

Organization of content, methods and evaluation, are influenced by a large variety of factors derived from the learner, the subject matter itself, the teacher and such practical aspects as time-tabling, facilities, school buildings and the like. Criteria for curriculum organization should take all variables into account.

3.5.6 Evaluation

Curriculum evaluation includes not only assessment of the learning done by pupils but also of the separate curriculum elements and of the total curriculum design itself. In simplistic terms a curriculum is judged to be successful if the instructional objectives have been attained at a certain predetermined level of achievement. Such a view of curriculum evaluation, propagated by the supporters of the so-called "behavioural objectives", is too limiting and provides no information about the many non-examinable aspects of education such as attitudes, appreciations, values and other desirable outcomes. Although it must be immediately admitted that many of the effects and outcomes of education, and thus of the curriculum, cannot be measured or even judged effectively, and that the long-term effects may never even be observed by those involved in curriculum design and implementation, progress towards the attainment of the more general aims should be evaluated.

The evaluation system, to be effective, should provide information on all aspects of the curriculum, including the general aims and objectives formulated. It is generally accepted that evaluation depends on objectives, but as Hooper³⁶ states,

Unfortunately, for education, the reverse is not true. The definition of objectives does not depend on evaluation. The sort of evaluation of objectives done by McNicol³⁷ reveals only too clearly the discrepancy between claims made for the curriculum and the actual results.

In developing the evaluation system for the curriculum certain criteria should be met. These criteria should form part of any complete theory for curriculum design. Apart from those obvious criteria of measurement and evaluation such as validity, reliability and objectivity, educational evaluation may be subject to other important criteria such as diagnostic value, facilitation of learning, provision of feedback data, and others. Although it may not be the concern of the curriculum theorist to analyse the different types of evaluation (e.g. diagnostic, formative and summative evaluation) or the variety of evaluation techniques (e.g. controlled testing, interviewing, case studies, etc.), the criteria devised and the guidelines provided for the design of the evaluation system, should form the basis for the selection and application of the evaluation types and techniques.

3.5.7 The relationship between the curriculum elements

The five elements of the curriculum are closely interrelated. Some of these links and relationships have already been pointed out. At this stage of the discussion on the development of a theoretical structure, it may be appropriate to indicate briefly some of the possible interactions between the elements.

1. Aims determine to a greater or lesser extent the selection of content and methods, the organisation of the curriculum, and the evaluation. The general aims and instructional objectives may, in turn, be revised, adapted or rejected in the light of information provided by the evaluation of all five elements.
2. The content may, apart from its influence on the selection of instructional objectives, also largely determine the methods selected, it may have a logical structure which can affect the organisation, and may determine to a large extent the type of evaluation suitable for assessing and measuring the learning outcomes expected of a particular subject area.

3. Organisation, based on different criteria, may have a wide range of effects such as selection of content and method to suit the developmental stage of the pupil, provision of units suitable for evaluation, and the revision of objectives.
4. Evaluation should, ideally, provide feedback on all the elements of the curriculum, including the evaluation itself, the latter by an objective, critical analysis of the results of the evaluation and of the value and suitability of the techniques employed.
5. The principles of methodology, being basic, general and over-arching, determine aspects of content, organisation, evaluation and the formulation of general aims and instructional objectives.

From this brief outline it follows that the elements cannot be developed separately, or even in a particular sequence.

At the outset, in the initial stages of curriculum design, a decision made about one of the elements may necessitate the revision of decisions already made in respect of the others; a change in one element as a result of evaluation feedback, may affect all the others.

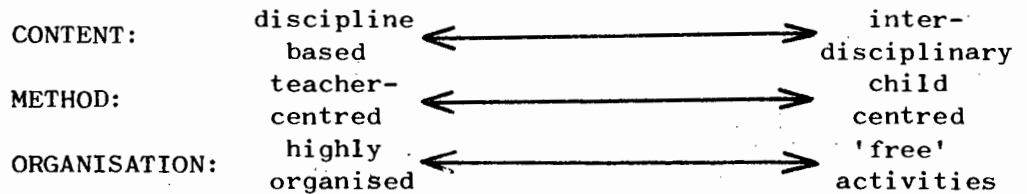
A detailed discussion of each element, and of the criteria and principles developed for the selection and design of the elements, will be given in Part II. Although this discussion will expose more detail about the relationships among the elements, three of these, viz. content, method and organisation, constitute a special set of interrelated elements which justifies separate discussion.

4. TEACHING-LEARNING ACTIVITIES

4.1 The special relationship of content, method and organization

The teaching process can, in practice, range from a highly structured, organized, discipline-based approach, such as the lecture, to the unstructured, loosely organized free-play

activity of the nursery class. Within this wide spectrum of educational activities it is possible to design many others, each one representing a different emphasis on content, rigor of method and level of organisation. These differences in emphasis may be represented thus:



The type of educational activity represented by the left-hand side of the spectrum is often referred to as "traditional", and that by the right-hand side as "progressive", but, as will emerge later, these labels may be misleading.

This special relationship between content, method and organization has been diversely named "learning experiences", "learning activities", "learning opportunities" and ^{by} other similar terms. These activities are, however, not only limited to the activity of the learner but also involve that of the teacher. They most often represent planned and controlled educational encounters between teachers and pupils - teaching activities designed to facilitate learning. It is thus proposed that the term "teaching-learning activities" be used to describe this relationship.

4.2 Curriculum models and teaching-learning activities

This interpretation of teaching-learning activities as composed of the interaction of the elements content, method and organization, applied to the "objectives model" and "encounter model" of the curriculum, produces the following pictures:

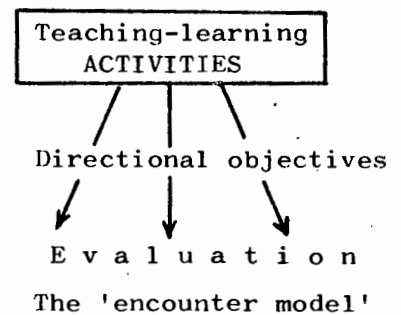
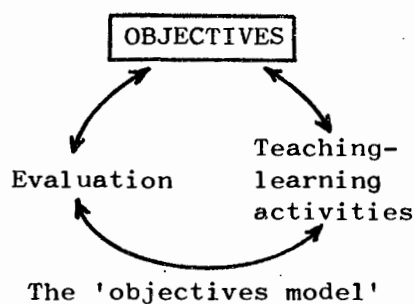


Fig. 4.1

Such an analysis reveals that these two "models" are not essentially different in their structure but only in the relative emphasis placed on objectives and teaching-learning activities. It would, therefore, seem possible to construct a unified model for curriculum design which will not only accommodate both these approaches, but may also give an indication of the relative value of these approaches for different purposes and needs.

5. A MODEL FOR CURRICULUM DESIGN

5.1 The basic structure of the model

The theoretical model for curriculum design proposed here, is developed specifically to provide a basis for the construction of curricula for the physical sciences. It is suggested, however, that the model may be evaluated and refined to serve as a universal approach to curriculum development.

The basic structure of the model may be represented in diagrammatic form:

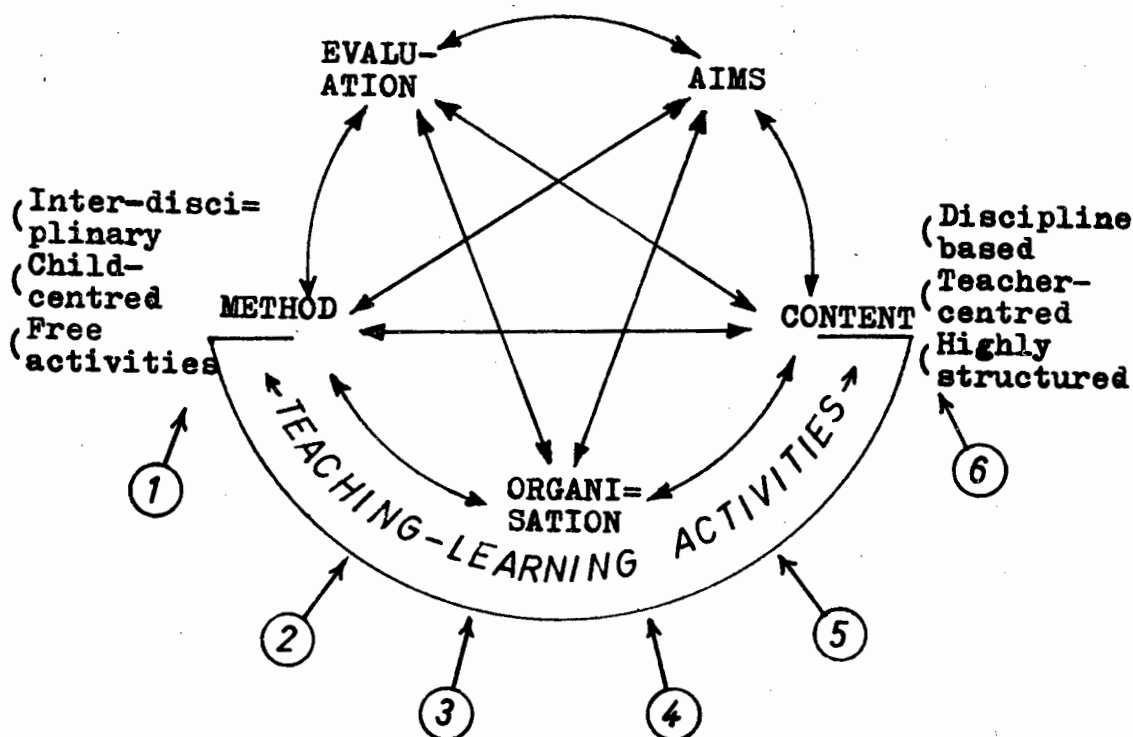


Fig. 4.2

5.2 Characteristics of the model

1. The model provides for five essential curriculum elements, viz.
 - (a) aims;
 - (b) content;
 - (c) organization;
 - (d) method;
 - (e) evaluation.
2. The diagram indicates that each of these elements cannot be treated in isolation but that they are closely interrelated.
3. The three elements, content, method and organization, form a special relationship, indicated by the term "teaching-learning activities".
4. The model can be applied to different levels of schooling as is indicated by the numbers 1 to 6. Number 1 indicates the type of balance within the teaching learning activities suitable for science education in a pre-primary (nursery school) situation. This involves, for example, a nature corner provided with suitable material to be observed and handled by the pupils. Learning takes place as a result of discovery and questions initiated by individual pupils themselves. At the other extreme, indicated by number 6, a lecture-type presentation at tertiary level is suggested. For the purpose of this model these two distinctly different types of teaching-learning activities will be called activity levels, and all the different possible activity types resulting from the variety of interactions between content, method and organization, will be called the activity range.

5.3 Detailed development of the model

The extremely complex nature of the curriculum, its five inter-related elements and even more interdependent facets, make it impossible to present more than the bare structural skeleton in diagrammatic form. For each of the elements, as well as for the identifiable relationship-patterns among the elements - such as teaching-learning activities - criteria for the selection must be established and principles for design and application be formulated. For this purpose each of the curriculum elements must be subjected to a detailed and critical analysis and study. Such an analysis and study, with the emphasis on the physical sciences, will be attempted in Part II.

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PART II: CRITERIA FOR THE DESIGN OF A CURRICULUM FOR PHYSICAL SCIENCECHAPTER 5MEANS AND METHODS FOR ESTABLISHING CRITERIA

When one comes to look at ways in which better courses might be constructed, the biggest difficulty arises right at the start, because there is no simple criterion to apply.

- F.R. Jevons¹

1. INTRODUCTION

It has already been pointed out that a sound model or theory for curriculum design is an essential prerequisite for rational curriculum planning. Curriculum design is a process based on a series of decisions representing choices from a range of alternatives and possibilities concerning each curriculum element and the interactions between these elements. Curriculum design process, as a series of decision-making procedures, is thus directly concerned with the application of criteria used in respect of these choices. Johnson puts it as follows:

Curriculum development is a process whose product is the curriculum and the process is concerned with how and by whom the curricula are developed. Curriculum process refers to the application of criteria for selection and ordering of curriculum items.²

The concern of curriculum theory is not with the "whom" but with the "how" of the design process, that is, with the establishment of criteria. The basic problems that confront the curriculum theorist at this stage are those of formulating such criteria and determining their validity.

2. SOURCES OF CRITERIA

2.1 Analysis of curricula

According to Taba³ an effective curriculum design should also make clear "what the bases of the selection and the emphases on the various elements are, as well as the sources from which these criteria are derived". This suggests that an analysis of existing curricula of physics, chemistry and physical science could provide a possible source for the establishment of criteria.

In attempting to follow this suggestion one is immediately confronted with a problem arising from the definition of curriculum accepted for this study. Only a few curriculum projects provide details on all elements of their curricula, including information about how to handle the selected content. Unless one has access to the originators of the curriculum in order to determine directly which criteria were used in the design process, this type of analysis is limited to those major curriculum projects about which additional articles and evaluations have been published. Even in these cases the information on criteria is often extremely meagre.

2.2 Analysis of curriculum literature

A search of the literature on curriculum design and development suggests itself as a source of criteria. Although many criteria can be found, such a search reveals a number of trends and problems:

- (a) Very few authors state the source of or the reasoning and rationale behind their selection of criteria. Together with the large amount of repetition found in different publications, this indicates an uncritical acceptance of many criteria. One could reason that these criteria are so well established, are based on such sound educational principles or have been proven sufficiently in practical application that their universality may be accepted. In the light of the fact that the references cited in many instances refer to the same original source, such reasoning may be suspect.

The impression gained is that certain criteria are generally accepted simply because of the status of the original author and that they have gained respectability through repetition.

- (b) Many criteria, especially those concerned with the selection and formulation of aims, are based on the authors' particular educational philosophy and life-view. Such criteria do not qualify for the requirements of a universal, unified theory for curriculum design.
- (c) Criteria for the selection and organisation of content and method are very often based on very diverse views on the nature of science as a school subject and on a different interpretation of and preferences for learning theories.
- (d) Not all curriculum theories identify the same set of curriculum elements. The criteria designed for "selection and organization of learning experiences" do not, for example, apply directly to the selection and design of the elements, "content", "method" and "organization". Similar problems arise from differences in interpretation of the meaning of the terms "aims" and "objectives", and of "evaluation" and "assessment".

2.3 Interviewing practising curriculum developers

First-hand information about the criteria employed in the actual decision-making process can be obtained from interviews and discussions with persons actively engaged in curriculum design. In order to obtain a representative sample of such workers one should be able to select from a fairly large number of countries. This would enable the interviewer to discard those criteria which are limited to local requirements and needs and select only those of general applicability and validity.

The implications of such a procedure as to cost and time are enormous. Fortunately such an opportunity presented itself to the author in the form of a study tour of Europe and the United Kingdom and the attendance at a course on curriculum development in science, attended by a large number of practising curriculum developers from a variety of countries.⁴

2.4 The original design of criteria

In the last instance it would be possible to design one's own sets of criteria based on the currently available data on educational aims, the structure of knowledge, the learner, the learning process, evaluation and other related studies. Each of these areas mentioned represent a wide and specialised field of study and such a task would be beyond the abilities of a single educationist. One could but suggest that such a combined effort at formulating criteria for the different curriculum elements by a team of specialised educationists would provide a major contribution to the development of curriculum theory.

3. METHODS EMPLOYED IN THE FORMULATION OF CRITERIA

3.1 Availability of sources

The decision on which methods to use for formulating criteria depends on the availability of the sources outlined in paragraphs 2.1 to 2.3. The dearth of suitable curriculum materials for the type of analysis suggested by Taba, has already been pointed out. In this respect, however, there is some related data available such as the surveys conducted by Cohen⁵ on the processes of chemistry curriculum development, by Strassenburg⁶ on the development of physics curricula, the investigation into the American PSSC, CBA and CHEM Study courses by the author⁷ and the Unesco series on "The Teaching of Basic Sciences".⁸

Literature on curricula is spread among specialised works on curriculum studies, other specialised and general books on aspects of education and in journals. Much of the work on science curricula has been reported in journals specialising in education in chemistry and physics.

The availability of these two sources, together with the opportunity of direct discussions with curriculum developers, made it possible to adopt a method combining the different sources of criteria.

3.2 Procedure for establishing criteria

The following methods were adopted in order to devise the criteria for the different elements of the curriculum:

- (a) Criteria were extracted from the analysis of existing curricula for physics and chemistry. This analysis was supported by the data obtained from the sources mentioned in paragraph 3.1 above, as well as those obtained from articles devoted to these curricula.⁹ The following curricula were analysed in this way:
1. Physical Sciences Study Committee (PSSC) physics;
 2. Chemical Bond Approach (CBA) chemistry;
 3. Chemical Education Materials Study (CHEM Study) chemistry;
 4. Nuffield Physics (revised edition);
 5. Nuffield Chemistry (revised edition and original version);
 6. Nuffield Physical Science (original version);
 7. Nordrhein-Westfal chemistry course (Germany);
 8. Nordrhein-Westfal physics course (Germany).
- (b) Criteria were obtained from educational literature. An effort was made to consult works representing a wide spectrum of educational thought, including authors from Great Britain, the United States of America, Germany, Holland and South Africa.
- (c) These lists of criteria were collated and arranged according to the five curriculum elements identified in Chapter 4. In this way five sets of "preliminary criteria" were obtained.¹⁰
- (d) Using these "preliminary criteria" as the bases for discussion, interviews with practising curriculum developers were conducted.¹¹ Each criterion was discussed and the arguments for the acceptance, rejection or amendment were carefully noted.
- (e) Interviewees were invited to suggest or add additional criteria to the lists. The reasons suggested for such additional criteria were noted.

- (f) The new sets of "draft criteria" obtained by these means, were edited and refined in order to remove duplication of criteria; those which could not meet the requirement of general or universal applicability were discarded.
- (g) An effort towards further validation could only be made on the basis of comparison and evaluation on the grounds of the proven or accepted principles of methodology.

3.3

The special problem of the selection of criteria for the formulation of aims

In the case of determining the criteria for the selection of curriculum aims a slightly different procedure was adopted. This was necessitated by the condition imposed on teaching aims in paragraph 2.2.3.2, namely that such aims, both in their sequence and totality, must contribute to the attainment of the ultimate aim of education. This ultimate aim, in turn, must be uncontaminated by personal philosophies, ideologies, creeds and dogmas in order to conform to the requirement of universality.

Consequently the selection and validation of criteria for the aims of the curriculum also depend on the ultimate educational goal favoured by the author. This approach encroaches on the field of philosophy of education, an area fraught with so many different points of view, that the criteria finally suggested may be rejected by some on philosophical grounds. However, since the criteria are designed to conform to the requirement of universality, they may be found to be adaptable to any ultimate goal of education, irrespective of its philosophical origin.

In the subsequent chapters the criteria and principles applicable to each element of the curriculum will be developed in detail.

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11. See APPENDIX II.

CHAPTER 6CRITERIA FOR THE FORMULATION OF AIMS AND OBJECTIVES

... It is essential to determine the pedagogic value and acceptability of such an educational goal in each case by applying certain criteria to it.

- C.F.G. Gunter¹

1. THE ULTIMATE AIM OF EDUCATION

1.1 Introduction

Following generally accepted usage in Education we distinguish between three main levels of formulation of educational aims, viz.

- (a) a single, ultimate aim of education;
- (b) a number of intermediate, general aims of education; and
- (c) a number of specific, instructional objectives.

This hierarchy has been outlined in Chapter 4, paragraph 3.5.2

In addition it is accepted

- (a) that the aims, including the ultimate aim, should be universally acceptable and applicable, and
- (b) that the intermediate aims and instructional objectives should contribute towards the attainment of the ultimate aim.

The first of these two conditions applies to the ultimate aim of education. One should also reflect whether there are or should be other conditions to guide or limit any arguments concerning the formulation of such an aim.

1.2 Conditions for an ultimate aim of education

The following conditions were accepted as essential requirements

to be met in formulating an ultimate aim of education. They were derived from the imposed condition specified above, and from an evaluation, in context of the observed facts of education, of criteria and conditions formulated by authors on the philosophy of education.²

1. An ultimate educational aim must relate to and be compatible with the nature of the educand, i.e. of the child.
2. It should be realistic in the sense that it must be directed towards the real needs of the individual, society and humanity, and not merely be a statement of some lofty, empyrean ideal.
3. An ultimate educational aim should be comprehensive enough to provide for all aspects of human existence, that is, an existence which is completely and uniquely human in all its implied aspects.
4. The ultimate aim should be inherently flexible in order to accommodate changing needs and circumstances. This does not imply that such a goal is temporary and needs to be constantly reformulated: the flexibility should be inherent in the formulated aim.
5. It should be universal and not limited to any particular life-view, political system or religion; at the same time each of these systems should be able to accommodate such an ultimate aim.

It is realised that these conditions will not satisfy all educationists. These conditions, in particular the last one, steer clear of any value-judgements and provide no indication of what the child ought to become, of the ultimate destination of man. This omission is deliberate and is not intended to reject the validity of including in education aspects beyond reality as we know it from observed facts. On the contrary, the inherent flexibility of the ultimate aim should provide for such extensions. These conditions, formulated within the context of Education as a science, are simply admissions of the limitations of science.

1.3 Existing formulations of an ultimate aim of education

The following list, based mainly on a summary compiled by Gunter³, contains ultimate aims formulated over the ages by various schools of educational thinkers:

- (a) Self-realisation of the individual as a rational, moral, harmonious and balanced person, achieved by leading a self-sufficient, rational life of thought, knowledge and culture for its own sake (the idealists).
- (b) Citizenship (the totalitarians).
- (c) Self-preservation and success in the struggle for existence in the world (the utilitarians).
- (d) The greatest amount of satisfaction and happiness to the individual, or to the largest group of individuals, without detracting from the satisfaction of others (utilitarian view of Barrow).⁴
- (e) Adaptation and adjustment of the individual to his environment for the self-preservation of the individual and the species (the naturalists and pragmatists).
- (f) Worldly wisdom and virtue (the humanists).
- (g) Preparation for a complete, perfect life on earth (Spencer).
- (h) Character-building (the moralists).
- (i) World-citizenship (the cosmopolitan).
- (j) Growth for its own sake (Dewey).
- (k) Social efficiency in a democratic society (Dewey).
- (l) Adulthood (the phenomenologists)⁵.

To these must be added the ultimate aims based on the different religions, e.g. the Christian ideal, the Judaic ideal and others.

With the possible exception of the aim "adulthood" none of those listed is acceptable within the limitations imposed by the formulated conditions since each one is derived from and based on a specific life-view not compatible with the requirement of universality.

Adulthood as an ultimate aim offers possibilities. At a first glance it seems to comply with the conditions imposed. It can be questioned, however, if development towards adulthood is a real, primary need of the individual, or rather a natural process of growth, development and maturation which is only aided, directed and catalysed by education.

1.4 Survival as an ultimate aim of education

1.4.1 The primordial aim of education

While it is not possible to say exactly when homo sapiens first emerged from the darkness of pre-historic times into the dawn of civilisation, there is sufficient evidence to indicate different stages of development from the primitive man of the Stone Age to modern Man of our century. From what can be reconstructed of these early times, and from the fact that Man, unlike some of his stronger contemporaries, has successfully survived through the ages, it may be concluded that education for survival was the first and primary purpose of the first instruction of the young.

It is also logical and reasonable to assume that the gradual development of Man was paralleled by a similar development in his education: the increasing complexity of life brought about by Man's ability to adapt and adjust the environment to himself, to record his history in pictures, symbols and words - to civilise himself - produced a need for a more comprehensive education.

The premise is thus submitted that the primordial aim of education can be identified as survival of Man. This ultimate aim of education, and this aim only, is as old as education itself.

1.4.2 The development of education and of its ultimate aim

It has been pointed out that the ever-increasing complexity of Man's society and environment - a situation created by himself - necessitated the simultaneous development of a more complex and comprehensive education. According to Rafferty

Each generation of Man takes what it needs from ... (what) ... its predecessors have toiled so painfully to build and to fill, and in turn erects its own, placing within its cell all that its own time has found good.⁶

It is only when education lags behind in this development and continues to provide an education aimed at survival for an era already past, that it fails in its ultimate purpose. This has happened in the past, and still happens, as Harold Benjamin's famous satire, "The saber-tooth curriculum" so admirably illustrates.⁷

The inherent flexibility of the aim "survival of Man" can absorb all that "Man" has toiled so painfully to build, the accumulated store of his knowledge, skill and culture, if it is accepted that the term "Man" means more than just the organism homo sapiens. "Man" implies all that which is uniquely human - the unity of body, mind and spirit - that which elevates Man beyond the animal world. Rephrased to remove any limitation in meaning, the original, ultimate aim of primitive education is still the aim of education today and of all future education:

the survival of Man as a uniquely human being.

Such a formulation provides for all possible aspects of education, such as physical, economic, cultural, social, emotional and political survival, as well as for survival of the society, the nation and the human race. At the same time this aim is universal and allows, for instance, the superimposition of the Christian ideal, of a democratic system of government, or for the complementary aims of any other creed or system.

2. GENERAL AND SPECIFIC AIMS

2.1 Different kinds of general aims

If agreement has been reached on the ultimate aim of education, the secondary, subordinate aims have to be formulated. At the first, highest level of the hierarchy they fall outside the terrain of the curriculum for a subject or of a subject-area such as physical science. This level of decision would require a formulation of the major contributing components of the ultimate

aim. These provide guidance as to the curricular, co-curricular and extra-curricular elements to be included in the educational programme. This level can be illustrated by means of the following examples:

GENERAL AIM FORMULATED	CURRICULAR ACTIVITY	CO-CURRICULAR ACTIVITY	EXTRA-CURRICULAR ACTIVITY
Physical survival	Health education; physical education	Medical and dental inspection, remedial exercises	Sports programme
Survival in a scientific-technological age	Physical science education	Science club	Scientific hobby

At the next level decisions have to be made about these specific activities, leading to the formulation of more aims, still general in nature, but more closely related to the subject, subject-area and the ancillary curricular activities. Such more proximate, general aims are derived from the answers to questions like the following: What is the contribution of physical science to the survival of man as a uniquely human being? What danger to this survival is inherent in the outcomes of physical science and the technology based on it? What structure of school physical science would serve best for education towards survival at different levels of maturity - a general, combined or integrated course of the physical sciences or the separate disciplines? At this stage the curriculum designer becomes involved. The question: "Why teach physical science?" must be answered, that is, the general aims for the teaching of this subject-area must be formulated.

Finally, each subject or subject-area, has its own particular structure and characteristics. The physical sciences, for instance, have a logical structure, their own methods, involve mathematical formulations and are experimental sciences. At this more specific level of subject matter and structure, aims have to be formulated about, for example, experimental work in the teaching of these subjects.

Thurber and Collette⁸ call these more proximate aims "long range subject objectives" and state that "they can be used to give continuity to the science program, and they can be of tremendous value in developing science programs". According to Nicholls and Nicholls⁹ they "serve the purpose of indicating the general direction of the course".

2.2 Specific aims

2.2.1 Introduction

Whereas the general aims of a curriculum indicate the general and broad intentions of the course, the specific aims refer to specifications of the knowledge, abilities, skills and attitudes the students should acquire as a result of their studies. Many of these, mainly skills and knowledge, should be possessed by the pupils at the end of the study and their attainment can be measured or assessed by means of suitable testing instruments. Others, like attitudes, are developed more gradually and are extremely difficult to assess. In these cases the intention is usually "to contribute towards" the attainment of these aims. Another characteristic of the specific aims is that they refer as a rule to sections and subdivisions of the curriculum rather than to the curriculum as a whole.

The terms "specific aim" and "objective" are often used synonymously, but in discussing a curriculum it is "usual to make a distinction".¹⁰ Both specify the knowledge, skills, abilities and attitudes to be attained, but curriculum objectives supply a much more detailed specification. The following example, adapted from Frazer¹¹, illustrates this difference:

	Curriculum item	Aim related to the curriculum item	Objective related to curriculum item
<u>Example</u>	Chemical equilibrium	To illustrate the concept of equilibrium, and to present the relevant thermodynamics.	By the end of the course the student should be able to - <ol style="list-style-type: none"> 1. calculate the partial pressure of gas at equilibrium, given the gas phase reaction, the value of k_p, and the partial pressures of all the other components. 2. etc.
<u>Comment</u>	The single word does not convey the scope, depth, detail and emphasis required.	Supplies more detail but does not make it clear what the students should be able to do at the end of the study.	To cover the topic 'chemical equilibrium' many statements of this type would be required. Final assessment is based on these objectives.

As Frazer¹² so aptly remarks, the main problem with specific aims and curriculum objectives is that of the level of specificity:

It is self-evident and uncontroversial that courses should have aims. However, when these are specified in a list, they often seem too broad and too vague to be of use in guiding either the teacher or the student

Aims may be too general but, on the other hand, there are many who believe that objectives are too numerous and too specific to be of much value in education ...

Because some consider that aims are too broad and objectives too detailed, intended outcomes of courses are sometimes defined at intermediate levels of specificity, and expressions such as goals, intermediate aims and intermediate objectives are used by some authors.

Since, according to our definition, the curriculum is also concerned with the ways in which content should be handled, clarity about objectives should be obtained before an attempt to formulate criteria can be made. In addition, as the example cited clearly illustrates, the detailed formulation of objectives can be interpreted as but another way of detailing content. This is obviously, then, an area of intimate interaction between aims and content, and a decision about objectives cannot be made separate from decisions about the content of the curriculum. A more detailed discussion of objectives is thus essential.

2.2.2 Curriculum objectives

Many different terms are employed to qualify or replace the term "objective". Some of these are the following:

- (a) instructional objectives;
- (b) behavioural objectives;
- (c) operational objectives;
- (d) performance objectives;
- (e) performance specifications;
- (f) learning specifications;
- (g) intended outcomes;
- (h) expected outcomes;
- (i) desired outcomes;
- (j) behavioural outcomes;
- (k) learning targets.

This problem of terminology, which is typical of educational writing, is very often caused by the different authors' interpretation of what is intended by the term "objective". This in turn reflects the lack of suitable criteria. "Instructional objective", for example, clearly implies that objectives are formulated for the teacher's use in order to guide him in the practical teaching situation; "behavioural objective" refers to the change in student behaviour to be achieved by application of the objective; "learning specification" seems to be directed more towards the learner and implies that the objectives should be formulated for the guidance of the student.

Objectives at this very specific level are concerned with the teaching and the learning and are devised to guide the teacher and the student. In addition, as has already been pointed out, the objectives also serve to specify the content. Objectives of this type, and the curriculum itself are thus both concerned with the same area of interaction, namely that between subject-matter, learner and teacher. A logical solution to the problem of nomenclature would be to refer to these specific objectives simply as "curriculum objectives".

2.2.3 Problems in writing curriculum objectives

During the last 10 years there has been a very strong movement among educationists in support of defining and writing detailed curriculum objectives. This trend has been reinforced by the development of individualised instructional techniques and methods such as "programmed learning", the "Keller plan", the "Audio-tutorial approach to learning" (AT) and "modular instruction". Three main reasons are usually advanced for breaking down specific aims into detailed curriculum objectives, viz.

- (a) it gives direction to the teaching;
- (b) it facilitates learning; and
- (c) it provides criteria for assessment.

These and other claims for curriculum objectives will be discussed in paragraph 2.2.5.

Instructions and guidance on the writing of curriculum objectives are supplied by various authors.¹³ Essentially they recommend the following:

- (a) Identify the behaviour of the student that may be observed or be a product of the student's efforts that may be examined.

If the focus is on behaviour the objectives should be introduced by verbs such as list, write, state, identify, classify, describe, etc.

If the focus is on a product the objectives should be formulated in terms of verbs like construct, make, design, prepare, etc.

Using the example in paragraph 2.2.1 this stage may be illustrated thus:

"By the end of the course the student should be able to -
1. calculate the partial pressure of gas at equilibrium..."

- (b) The next stage is to identify and describe the conditions under which the student is to work. Adding the conditions to the example given above, one would state:

"... given the gas phase reaction, the value of k_p , and the partial pressures of all the other components".

- (c) Thirdly, the level of performance (outcome) expected should be stated, e.g. the percentage of accuracy required, the number of items to be recalled or listed, what level of achievement is expected, and so on.

Implicit in these statements of curriculum objectives is also a specification of time: "By the end of the course .."

From this very brief review some of the problems in writing curriculum objectives are already apparent. The main problem areas may be summarised as follows:

1. The curriculum objectives must be consistent with the aims of the curriculum. This requires that these detailed objectives should be considered not only individually but also whether they cumulatively lead towards the more general aims.
2. All the aims of the curriculum should be included in the curriculum objectives. A survey of curriculum objectives reveals a tendency to include only low-level objectives such as recall of knowledge and application of simple skills, and to ignore objectives relating to high-level abilities and attitudes. The reason for this is simple: it is extremely difficult, and according to some authors¹⁴ impossible, to formulate behavioural-type objectives for these higher abilities.
3. An appropriate and optimum level of specification should be reached. Objectives which are too detailed may lead to the

compilation of long, unwieldy lists of trivial learning tasks. If, on the other hand, the objectives are too general, they give little direction to the teacher and learner, and assessment of whether they have been attained becomes extremely difficult.

2.2.4 Classification of curriculum objectives

Various efforts have been made to classify curriculum objectives. The purpose of such classifications is to enable teachers to obtain clarity about their immediate instructional objectives and to aid students in acquiring the type of learning specified by these objectives. The classifications and taxonomies were received with much greater enthusiasm by faculties of education than by classroom teachers. Harbo¹⁵ remarks that "the most zealous spokesman for educational objectives in behavioural terms had to admit that ...(they)... failed to have any dramatic effect on the educational community" and that Bloom's taxonomy of educational objectives from 1956 had sales figures "surprisingly modest ...". The classical books by Bloom and Krathwohl¹⁶ are the best-known of these efforts at classification, and have had perhaps the greatest influence in educational circles. Examples of this influence are the restatement of Bloom's hierarchy of cognitive objectives in terms of physics by the Scottish Certificate of Education Examination Board¹⁷ and its use in Curriculum Paper 7¹⁸ and in German curricula¹⁹. Locally Bloom's taxonomy was also used by the Cape Education Department as one of the bases for differentiation between the higher and standard grades of physical science and in the design of a test-item bank by the Human Sciences Research Council (HSRC).²⁰

The works by Bloom and Krathwohl are, however, written in general terms and, unless the classifications are rewritten very clearly in terms of the content of the physics and chemistry included in a curriculum, they may appear remote from the physical science taught in the classroom. Very often, too, the emphasis is on the cognitive domain only, disregarding the affective. This is exemplified by both the Scottish and German efforts towards rewriting the taxonomy for the purposes of science education.

Other classifications have been suggested and reviewed in the literature.²¹ Frazer²² suggests that a simple scheme of

classifying curriculum objectives under three headings may appeal more to the average teacher:

1. Knowledge and understanding.
2. Skills - (a) intellectual, e.g. problem defining and solving;
- (b) manual, e.g. handling apparatus.
3. Attitudes.

The appeal may be largely in the simple terminology employed, but this classification does not differ essentially from Bloom's three domains, viz. cognitive, affective and psychomotor. A similar classification was used in a Working Party Report of Jordanhill College, 1976²³:

1. Skill objectives - what the student should be able to do;
2. Knowledge objectives - what the student should know;
3. Attitude objectives - the disposition of the student to act in certain ways.

They add that "objectives of these three types must not be seen as separate and distinct".

For the construction of a curriculum it is essential to have available an effective system of classification. It is necessary to analyse each topic or aspect as to content, method and organization in order to decide which class of objective may possibly be attained by its teaching and learning. In the teaching of physical science, a typical experimental science, the skills aspect of practical work may be of major importance. Similarly, clarity has to be obtained not only on the attitudes one would like to inculcate, but, equally important, which of these attitude objectives are naturally suitable and possibly achievable through a study of physical science.

The classification also has implications for evaluation. While it is a fairly uncomplicated task to assess the knowledge and skills aspects, the evaluation of the attainment of attitude objectives is a very complex and difficult task. Whatever objectives may be written in a curriculum, teachers as well as students will concentrate on those evaluated in tests and examinations, and thus, unless the attitude objectives are evaluated as well, they will receive relatively little attention in the

practical teaching-learning situation.

2.2.5 Behavioural curriculum objectives

In order to make a decision about behavioural type curriculum objectives for physical science, the curriculum theorist should obtain clarity about the real value of these objectives.

Frazer states that

Much has been written in favour of, and against, the procedure of defining objectives, and occasionally the debate seems to be more emotional than rational. It is necessary to consider two levels: (a) opinion (albeit opinion expressed logically and on the basis of classroom experience) and (b) experimental studies.²⁴

The following advantages are generally offered in favour of behavioural objectives:

1. The student is clear what he has to achieve.

The student does not have to guess from a syllabus, the textbook or past examination papers. He can concentrate on learning, knowing exactly what is expected of him. The objectives can help him to make a decision about electing a particular course of study.

2. The objectives are an aid in planning.

By forcing the teacher to think about what he wants the pupils to learn, he can plan his work thoroughly.

"This is perhaps its greatest advantage".²⁵

3. Teachers and students are in harmony.

There is no confusion about what each is trying to achieve and the student is not confused when incidental or illustrative material is included or presented.

4. It is easier to select the course content and methods.

The objectives specify the content to be selected and, knowing the required outcome, the teacher can devise or select his teaching methods accordingly.

5. The objectives enhance individual instruction.

Individual and remedial instruction is easier to design on the basis of behavioural objectives.

6. The type and method of assessment is defined by the objectives

The teacher or examiner knows exactly what to include in the examination and the candidate has clearly defined objectives to prepare for. It also becomes possible to evaluate more effectively the success of the teaching methods.

The major disadvantages may be summarised as follows:

1. The performance specifications are limited in scope.

Education is not training and there are many desirable outcomes of education which cannot be described in terms of changes in behaviour or of terminal performance of pupils. Many of the effects of education may not manifest themselves for many years after a course is completed or are only slowly developed in a cumulative manner. All this applies mainly to aims and objectives in the "affective domain" (Bloom) or in the area of "attitudinal objectives" (Frazer).

Even in the area of abilities it is far easier to write objectives for those of the low-level type, such as recall of knowledge and manipulative skills, and consequently the higher abilities tend to be neglected.

2. Individual students will exhibit different behaviours as a result of the same teaching-learning experiences.

Pupils not only do not derive the same benefit from any particular teaching-learning experience, but very often also exhibit different terminal behaviours. Pupils should be free to derive more than the specified behaviours from their studies.

3. Objectives that are too specific are no more than a detailed topic list

Behavioural objectives that specify a multitude of outcomes appear trivial as a "target" for learning and education and simply replaced the topic list of the traditional syllabus. This is clearly illustrated by comparing the

1963 and 1973 versions of the "Curriculum Chemie" of the Nordrhein-Westfalen (Germany) Gymnasia. The former is a list of topics, whereas the latter contains similar topics expressed in the form of more than 800 behavioural type objectives.²⁶

4. Specified objectives lists are too long and confusing.

The length of such lists is amply illustrated by the example quoted above. Such long lists may confuse and overwhelm the student and thus be barriers to purposeful learning.

5. Students react unfavourably to the "spoon-feeding" which is implied by, and very often results from, this approach.

This is particularly true of pupils of the upper-ability range. The limited scope and highly specified nature of each objective guide and direct the teacher to a very narrow and clearly defined approach to the teaching of each topic.

6. Behavioural curriculum objectives do not reveal the structure of knowledge in any subject.

This fragmentation is caused by the fact that relationships and interactions between the various parts of a particular body of knowledge cannot easily be expressed in terms of this type of objective.

There are many sources available on the merits and disadvantages of objectives of the behavioural type.²⁷ Summarising these, one may conclude that there is general agreement on the advantages of behavioural objectives for

- (a) day-to-day course planning in the classroom; and
- (b) specifying criteria for assessment and evaluation.

Disagreement occurs on

- (a) the claim that these objectives assist the learning process; and
- (b) whether or not detailed topic lists can do many of the things claimed for behavioural objectives.

One would like to turn to experimental studies on the use of specified objectives in order to obtain clarity about the various claims and objections. Unfortunately there are formidable problems

in designing suitable experiments to test many of these claims and, according to Frazer²⁸, "it is unlikely that there will be a definite answer from experiments covering all subjects and all levels and types of learning". The present position, as reviewed by Duchastel and Merrill²⁹, Walbesser and Eisenberg³⁰ and Boardman³¹, may be summarised as follows:

- (a) There are about an equal number of research reports indicating that learning is, or is not, enhanced by stating detailed behavioural objectives.
- (b) No differences in achievement could be found between matched groups of students supplied with, and not supplied with, detailed objectives.
- (c) Many of the experiments themselves were poorly designed and could be rejected or criticised on aspects of design, implementation and the conclusions arrived at.

Perhaps some of the best examples of high school curricula based in their design and evaluation on behavioural objectives, are those of Nordrhein-Wesfalen in Germany³². In addition they are also based on Bloom's six categories of the cognitive domain, viz.

- (a) knowledge (Kentnisse), (b) comprehension (Verstehen),
- (c) application (Anwenden), (d) analysis (Analyse), (e) synthesis (Synthese), and (f) evaluation (Bewerten). From an analysis of these curricula for physics and chemistry one is struck by the resemblance to a detailed topic list and by the artificiality of some objectives. For example, in Theme V: Activity series of metals and non-metals, one finds the following:

The pupil shall

- suspect that the differences in reactivity of the metals with acids and the production of hydrogen may be determined quantitatively
- investigate this supposition experimentally.³³

It is not clear how the first of these two behaviours, namely to suspect (vermuten) or obtain a feeling for quantitative expression from a series of observations, can be achieved unless this is supported by a series of preceding investigations.

These are missing from the list of objectives. Many other examples of objectives introduced by the verb "vermuten" can be found in this curriculum.

2.2.6 Formulation of curriculum objectives

The curriculum theorist should make a decision about the curriculum objectives in the light of the different opinions and available evidence, as summarised above, in order to decide which level of specification is required. The finer the degree of specification, the more detailed will be the classification or taxonomy that can be used for distinguishing between the different categories of objectives.

From the reasoning behind the opposing claims, and based on the meagre evidence available, the author proposes the following approach:

1. Curriculum objectives should be specific enough to provide the teacher with clear guidance and direction regarding
 - (a) the interpretation of the content and topics to be taught and studied;
 - (b) the type, scope and depth of evaluation and assessment;
 - (c) the attitudes that should be pursued in the teaching, to which the content and nature of the subject are particularly suitable, which content or topics lend themselves to development towards attainment of the attitude objectives and the evaluation of the attitudes;
 - (d) the skills to be developed which are consistent with the nature of the subject and the evaluation of these skills.
2. Highly specific and detailed behavioural objectives have no proven advantages over a detailed exposition of content and may have certain disadvantages. It is the author's opinion that the framing of detailed instructional objectives is the task of the teacher and not of the curriculum designer. The curriculum should indicate approaches and general

methodics but that the prescriptive nature of behavioural objectives hampers and stifles the teacher's personal teaching style and unique methods and techniques.

This approach may be exemplified by the theme "Atomic structure and chemical bonding" from the Nordrhein-Westfalen chemistry curriculum.³⁴ This section, which excludes metallic bonding, comprises about 60 behavioural objectives. This list may be effectively reduced without distracting from the clarity of guidance to the teacher or pupil by replacing the objectives with a detailed topic list and the following curriculum objectives:

The pupil should be able to

- recall the listed facts about Dalton's, Rutherford's, Bohr's and the orbital model of the atom
- recall the listed facts about the differences in nature of the various chemical bonds
- recall the relationships between bonding and the structure of solids
- appreciate that explanations of chemical reactions without the use of models are not possible
- realise that the models are not necessarily final representations of our understanding and that they may be modified in the light of new evidence
- apply the atomic model to explanations of chemical bonding in substances familiar to the students
- apply the concepts electronegativity, electron affinity, ionisation energy, lattice energy, exothermic and endothermic to concrete examples of bonding in salts ... etc.
- recognise and identify the relationships between the structure of a substance, its properties and the chemical bonding involved.

These eight specific objectives have been phrased in the terminology of behavioural objectives but may just as effectively be stated in a different form, e.g.,

the objectives of this section are:

- (a) the recall of the listed facts about Dalton's, Rutherford's, Bohr's and the orbital models of the atom ..
- (b) an appreciation of the use of models to make the explanation of chemical reactions possible ..
- (c) the application of the concepts of electronegativity, electron affinity, etc. to examples of bonding in salts ..
etc.

An example of the use of curriculum objectives of this type can be found in the curriculum for General Science for the Senior Primary Phase of the Department of Education, Cape of Good Hope, 1977.³⁵ In this document the content topics are listed in one column and adjacent to it clear and specific objectives, together with the suggested and recommended methodics, are supplied in another column. Very clear and explicit guidance is given without resorting to an extensive list of behavioural objectives.

Although this approach does not exclude the use of a fairly detailed classification such as Bloom's, it would be better suited to a simplified form of taxonomy, either based on that of Bloom, e.g. as that used by the Scottish Certificate of Education Examination Board, or the simple classification proposed by Frazer. Although the latter may serve the purposes of the classroom teacher, the former is of greater value in making decisions on assessment of the students' achievements.

Summarising, then, the following approach is suggested:

1. The formulation of a limited number of clear and specific curriculum objectives for each topic or section of the curriculum content;
2. the replacement of an extensive list of highly specified behavioural objectives by a detailed topic list which allows for no ambiguity in interpretation;
3. the use of a simplified form of classification of objectives, but detailed enough to provide clear guidance for evaluation purposes;
4. the written statements of curriculum objectives should be known to teachers and students in order to have an effect on the teaching and the learning;

5. the evaluation and assessment should be based on and reflect these objectives.

3. CRITERIA FOR CURRICULUM AIMS AND OBJECTIVES

3.1 Introduction

The methods used for obtaining criteria were explained in Chapter 5. It would be repetitious and serve no purpose to list all the criteria derived from the various sources.³⁶ Instead a representative sample, covering the criteria found, will be used as the basis of discussion.

3.2 Criteria derived from analysis of curricula

Eight curricula in physics, chemistry and physical science from Great Britain, the United States of America and West Germany were analysed in order to extract criteria for curriculum objectives.³⁷ The following criteria, either explicitly stated or implied, could be identified:

1. The objectives should reflect the structure of knowledge represented by the subject (all curricula).
2. The objectives should be directed towards the pupils' interests and needs (all curricula).
3. The objectives should be in agreement with what is known about the learning of science in schools (Harvard Project Physics; Nuffield).
4. The objectives should be socially relevant (Harvard Project Physics; Nuffield).
5. The objectives should be specified with a high degree of precision (Nordrhein-Westfalen).
6. The objectives should provide for a wide range of abilities, interests and needs (Harvard Project Physics).

It may be possible to extract other implied criteria, but it would be extremely difficult to justify them in terms of the real intentions of the curriculum developers.

3.3 Criteria derived from the educational literature

3.3.1 Criteria formulated by the phenomenologists

The list of criteria presented here, is one compiled by Gunter.³⁸ Although these criteria are not directly related to "curriculum objectives" but to "educational goals", he states that the curriculum is the means of attaining these goals.³⁹

1. The objectives should be concerned with reality as it ought to be. This means that every objective "must link up with and be properly related to what is given, i.e. with what the child is and is capable of, his general and specific nature, his gifts, disposition and inner possibilities and his needs, knowledge and experience at every stage of his advancement to adulthood".
2. Every partial objective must take into account and provide for the real needs and interests of the individual as a member of a community (society).
3. Every objective must be essential and serve to attain the chosen goals (i.e. the general aims and ultimate aim).
4. Every objective should constitute a challenge or appeal to the child. It should "add momentum and give direction to the life-urge in him .. call upon and inspire him to give of his best, and activate him to work, effort and sacrifice".
5. Every objective must be a definite plan of action.
6. Objectives should be flexible (easily changeable) in order to take into account and to deal with changed circumstances, problems and needs.

3.3.2 Criteria formulated by authors of general educational works

Two examples, one British and the other American, are provided.

(a) Smith, Stanley and Shores (1957), American⁴⁰:

1. The criterion of social adequacy.
2. The criterion of basic human rights.
3. The criterion of democratic ideals.

4. The criterion of consistency and non-contradiction.

5. The criterion of behaviouristic interpretation.

(b) Wheeler (1967), British⁴¹ :

This author distinguishes between aims and objectives.

The following criteria for aims are given:

1. Consistency with human rights.

2. Democratic orientation.

3. Social relevance.

4. Individual needs.

5. Balance.

No criteria for objectives are given, but the behavioural type of objective is propagated, which is thus closely related to objective criterion 5 of Smith et. al., above.

The similarity with respect to the other criteria is obvious.

3.3.3 Criteria formulated by curriculum experts

(a) Hilda Taba⁴², 1962

1. A statement of objectives should describe both the kind of behaviour expected and the content or the context to which that behaviour applies.

2. Complex objectives need to be stated analytically and specifically enough so that there is no doubt as to the kind of behaviour expected, or what the behaviour applies to.

3. Objectives should be so formulated that there are clear distinctions among the learning experiences required to attain different behaviours.

4. Objectives are developmental, representing roads to travel rather than terminal points.

5. Objectives should be realistic and should include only what can be translated into curriculum and classroom experience.

6. The scope of objectives should be broad enough to encompass all types of outcomes for which the school is responsible.

(b) Goodlad and Richter⁴³, 1966:

1. Validity, in terms of societal, professional and industrial needs.
2. Relevance, in terms of the changing characteristics of pupils.
3. Appropriateness, in terms of our increasing knowledge of psychological processes.
4. Precision, in terms of the specificity with which they are expressed.
5. Comprehensiveness, in terms of their coverage of the intentions of the curriculum designers.
6. Consistency, in terms of their internal supportiveness and lack of contradiction.
7. Feasibility, in terms of availability of facilities, personnel and costs for implementation.

3.4 The list of preliminary criteria for curriculum objectives

A list of "unrefined" criteria was drawn up to be used as a basis of discussion with different curriculum workers. Some explanatory remarks were added to each criterion in order to avoid differences of interpretation. Although some of the criteria may overlap, e.g. that of "precision" and "behaviouristic" and of "consistency" and "should contribute towards general aims and ultimate aim", these pairs of related criteria are not exactly similar and it was felt that the differences in emphasis might enhance fruitful discussion.

Criterion 1: Curriculum objectives should lead towards and contribute to the attainment of the more general aims and the ultimate aim of education. The general aims referred to may be on the level of the subject (physical science), the subject area (science), the school, community, country and the religious and State systems operating in that country. In this sense this criterion is similar to Taba's that objectives should be developmental,

i.e. representing roads of travel rather than terminal points, or to Meinel's⁴⁴ criterion of convergence, i.e. all objectives and aims should converge in a single focus, the ultimate aim of education.

Criterion 2: Curriculum objectives should be valid expressions and reflections of societal, professional, industrial and national needs.

This criterion should be critically judged within the context of the teaching of school science. This can be exemplified by the CHEM Study objective that the course should mirror the work of the professional chemist, i.e. the assumption that "any significant behavior which can be derived from analysis of an academic discipline can be learned by students of a given age and is, therefore, worth learning".⁴⁵ The validity of such an assumption, and therefore of the objective itself, should be critically examined. Similar objectives relating to society, industry and the needs of a country can be found in various curricula for the physical sciences.

Criterion 3: Curriculum objectives should be appropriate to our existing knowledge of educational psychology.

Objectives should be scrutinised in order to determine whether they are appropriate to the readiness of the pupil, and are in agreement with what is known about the learning process. One could, for example, question objectives of the type, "the pupil should discover for himself ..." on the grounds that the advantages of self-discovery methods over other methods are not proven beyond any doubt.

Criterion 4: Curriculum objectives should be expressed with a high degree of precision and specificity.

This is essential in order to remove any ambiguity in interpretation. An objective such as "the

development of laboratory skills" does not, for example, indicate which laboratory skills are required for the particular level of instruction or for the particular course.

Criterion 5: Curriculum objectives should be expressed in terms of the kind of behaviour expected of the student, as well as of the content and context to which the behaviour applies. According to this criterion curriculum objectives should be of the behavioural type (Mager) or in the form of "process objectives". Instead of an objective such as "to be able to use the burette" one expressed in terms of an expected behaviour should be formulated, e.g. "At the end of the laboratory programme the pupil should be able to measure a stated volume of liquid from a burette within an accuracy of 1 per cent".

Criterion 6: Curriculum objectives should be comprehensive and provide for a wide range of abilities, interests and values. In addition to provision for the different abilities and interests of pupils, the curriculum for the physical sciences should also include objectives concerned with the personal, social, economic and moral implications of physics and chemistry.

Criterion 7: Curriculum objectives should be relevant to the characteristics of the pupils. This criterion requires a consideration of the pupils in the world of today, of their social mores and their environment in a technologically complex age of rapid change.

Criterion 8: Curriculum objectives should be flexible and changeable in order to provide for new knowledge and understanding. New information and understanding about the subject itself, the learner and the learning process, teaching and instructional techniques, are constantly developed.

Curriculum objectives should provide for these new developments.

Criterion 9: Curriculum objectives should be internally consistent and non-contradictory. The objectives formulated to attain the aim of "scientific literacy for all citizens" could be contradictory to those formulated to attain the aims of a course designed "to prepare professional scientists". This criterion has important implications on the question whether a single curriculum directed at "mixed ability" pupils is feasible or even desirable.

Criterion 10: Curriculum objectives should be realistic and feasible in terms of attainability and practical implementation. This criterion is clearly explained by Taba as "including only what can be translated into curriculum and classroom experience". In applying this criterion one should take into account the attainability of an objective, e.g. the aim "to develop useful and responsible citizens" may be impossible to attain by the teaching of physical science, and needs to be rephrased to provide clearly for the contribution physical science can make towards the eventual attainment of this aim. In addition, aspects such as cost, facilities, equipment and personnel should be taken into account when curriculum objectives are formulated.

3.5 The refinement of the criteria

The refinement of the criteria was carried out by discussion with various curriculum workers, educationists, and by an analysis of the available literature on this subject. The order of discussion is that in which the criteria were listed in paragraph 3.4, but, for the sake of convenience, they are identified by a single word or short phrase and not stated in full.

3.5.1 The criterion of convergence

There is general agreement that the objectives for a curriculum for the physical sciences (physics, chemistry or a combination

of these two) should not be divorced from the "primary aim of school education".⁴⁶ Very few practising curriculum developers were prepared to compromise themselves on any statement of an ultimate aim of education, but were prepared to accept the criterion if consensus on such an aim could be obtained. The Weizmann Group⁴⁷, for example, see as the primary aim of education in Israel, "to form an integrated nation from people of a variety of backgrounds, countries and cultures". The teaching of a natural science is a compulsory component of their school courses because "science is an essential part of the modern and future world". The preparation of future scientists is high on their list of curriculum aims, although "it may conflict in some respects with the aim stated above, both purposes have to be served in our country". In a concluding statement on criteria for curriculum objectives, this group remarks:

Criteria would change as the needs of the country change and we are not prepared to compromise ourselves at this stage. But one criterion would perhaps always be that the objectives of a science curriculum should be closely related to and contribute to the national educational aims.⁴⁸

On the European Continent and in Great Britain one finds increasing emphasis on "expanding the aims of science teaching"⁴⁹ and agreement that the objectives for a curriculum should lead towards these "expanded aims". According to Gunnell⁵⁰ the application of principles, the social functions of new (scientific) knowledge should be included as essential parts of the science curriculum. He states that these trends are not primarily due to educationists but rather to "social pressures arising from the increasing public political debate of areas in which the effect of scientific development is actually or potentially harmful. The environmentalist/conservationist lobby has become internationally and nationally significant and has affected the politics not only of science but of science education". Questioned on whether the need for these outside pressures would have arisen if the objectives of science education were formulated to lead towards a broader, ultimate educational aim, i.e.

one which provides for individual, social, cultural and national development, he admitted that such an approach would perhaps lessen these pressures, "although one could foresee many difficulties and differences in opinion as to what should be considered a desirable final goal".

The general impression gained from the variety of interviews conducted is the following:

- (a) In West Germany, the Netherlands and the United Kingdom there exists a multitude of "desirable aims" for education and the curriculum objectives are determined largely by outside pressures. The curriculum objectives are extremely sensitive to socio-political pressures. With the exception of the specialized senior secondary courses, such as the British "A-levels" and the German "Gymnasiale Oberstufe", where the aim is obviously academic preparation of subject specialists, there is little evidence of an accepted ultimate aim of education, except, perhaps, for an increasing emphasis on a "general education" for "mixed ability intake". Those interviewed agreed, however, on the need and purpose of the criterion of convergence, but differed, often vehemently, on the aims of science education in general and on the ultimate aim of education in particular.
- (b) In the Scandinavian countries there is a clear, prescribed set of national socio-political aims in which the aims and objectives for the science curriculum have to operate. In France a similar situation was observed, but the "national" aims are less clearly defined than in the Scandinavian countries. (Curriculum developers from these countries, too, agreed to this criterion.)
- (c) The position in the developing countries is somewhat different. The emphasis seems to be on the immediate needs of these countries and the structuring of science curricula with immediate and short-term advantages. The influence of educational aid through such agencies as The British Council and Unesco is obvious from both the materials and the discussions held with educationists from some of these countries.⁵¹ The criterion of convergence is accepted for

as far as it leads towards the realisation of the immediate aims directed at solving the short-term needs of these countries.

- (d) The position in the United States of America and Canada is comparable to that summarised for West Germany, the Netherlands and the United Kingdom. At McGill University in Montreal, Canada, criteria for the selection of objectives are formulated, including one similar to convergence.⁵²

All the literature consulted either agrees with the criterion of convergence directly or by implication. The latter may be exemplified by statements such as "consistency with basic human rights", "social adequacy or relevancy" and "democratic orientation". As these statements are declarations of what these authors consider the aims of education should include, these criteria are only more detailed expressions of the criterion of convergence.

More directly, one finds support for the criterion of convergence from authors such as Frazer⁵³, Taba⁵⁴, Michaelis *et. al.*⁵⁵, Tricker⁵⁶, and others. Philosophical arguments are summarised by Gunter⁵⁷, covering the points of view of the naturalists, idealists, pragmatists, existensialists and the phenomenologists.

One could argue that this criterion is logically self-evident. According to the approach favoured by the author in Chapter 4, paragraph 3.5.2, this criterion is a sine qua non, and the arguments quoted in this section bear out its general acceptance.

3.5.2 The criterion of validity

This criterion is an extension of Goodlad and Richter's "validity, in terms of societal, professional and industrial needs". In discussing this criterion with curriculum workers it was stressed that many curriculum objectives in physical science could be termed "desirable" or "worth-while" but that they would not be valid if they were based on assumptions about these needs which are themselves wrong or unproven. In addition, even if they are based on real needs, the subject matter itself, or the structure of the subject at school level, may not lend itself to the attainment of such objectives.

In his discussion of this criterion, Cohen⁵⁸ concentrates on the assumption that the "objectives of school chemistry should mirror the work of the professional chemist". He points out that these objectives apply to CHEM Study, CBA and to Nuffield Chemistry. He not only questions the validity of the basic assumption but quotes evidence of a possible distortion of values as a result of this assumption, resulting in important and unintended outcomes such as the over-emphasis of direct experience at the expense of other problem-solving techniques and an erosion of interest in fine arts and literature.

Tricker⁵⁹ takes up the validity of the objectives for practical work in science and states that the purpose of practical work should be to prepare the pupil to think scientifically in the context of a practical situation, and to derive a sensible procedure to tackle a question with which he has been presented. He concludes that the many process objectives directed at simple procedures such as the ability to connect up a circuit according to given instructions, form a very minor ingredient in the qualifications necessary for the practical scientist and that it "is a waste of time and opportunity to limit the pupil's own practical studies to such a mean intellectual level". Although Tricker's views are open to criticism, the validity of objectives stated for practical work in school science courses may be questioned on various grounds.

The criterion of validity of curriculum objectives was generally supported by all the curriculum workers and educationists interviewed. It was felt by some that the preliminary formulation supplied as a basis of discussion requires re-thinking and re-formulation. When confronted with Goodlad and Richter's original formulation, many of the objections remained. It was felt that the term "needs" does not adequately describe everything implied by this criterion. One suggestion⁶⁰ was to change the criterion to "validity in a societal, professional and industrial context".

3.5.3 The criterion of appropriateness

The preliminary formulation of this criterion caused a number of problems of interpretation. It was pointed out by some that the

author's interpretation goes beyond that of Goodlad and Richter. After reformulation, based on a statement from Thurber and Collette⁶¹, namely "appropriateness in terms of the maturity and backgrounds of the pupils", this criterion was generally agreed to.

~~/~~^{During} discussion about the original statement that "curriculum objectives should be appropriate to our existing knowledge of educational psychology" it was suggested that this belongs to the criterion of validity and that the words "educational" should be added to read "validity in a societal, professional, industrial and educational context".

In the end it was agreed that the criterion of appropriateness refers to the age, maturity, readiness, existing knowledge and understanding, intelligence and social, cultural and economic background of the pupils. This conclusion is in line with that of Cohen where he states:

On the criterion of appropriateness of objectives, psychological readiness of the learners is paramount.

In this connexion, the emphasis of secondary-school chemistry curricula upon chemistry as a discipline has been denounced by Smith⁶² as a "kind of precocious role playing".

As an example, ability to understand abstract chemical theory demands a particular level of concept development.⁶³

3.5.4 The criterion of precision and specificity

Every curriculum worker interviewed agreed that curriculum objectives should be expressed with the highest degree of precision possible. It was pointed out, however, that the specification of objectives could lead to fragmentation of the curriculum and loss of unity. The Weizmann Group felt very strongly that the greatest amount of specification should be reserved for teachers' guides only, and that detailed specification should not be made available to the students. They argued that the majority of high school pupils entering for an external examination will limit their studies to these specified objectives and thus lose much of the other educational advantages of the course.

With a few exceptions among both groups, a very high degree of precision and specificity of the behavioural type of objective, was favoured by curriculum workers attached to faculties of education, whereas those still actually engaged in classroom teaching were not in favour of such a detailed specification of objectives.

With the co-operation of some members of the Leeds group⁶⁴ a discussion was arranged in order to attempt the formulation guidelines for the optimum degree of specification required. Although some valuable thoughts were offered, no general agreement could be reached. The following two suggestions gained the most support:

- (a) Each major aim of the curriculum should be analysed in depth in order to specify the contributing objectives with precision and clarity;
- (b) each section or subdivision of the curriculum should first be analysed and suitable objectives should then be designed on the basis of Bloom's taxonomy.

During a conference concerned with framing guidelines for comprehensive schools in Nordrhein-Westfalen the Kultusministerium (Ministry of Education) made the political decision that Von Hentig's⁶⁵ catalogue of aims should form the basis of the search for curriculum objectives. Referring to this conference Jung⁶⁶ states that the discussion of aims and objectives should be linked to the process of implementation and that the classroom teacher should be convinced and well-informed about the relationship between the objectives and the "philosophy of the new curriculum". He adds:

And to my mind this should not be done by subjecting him (the teacher) to a massive bombardment by statements purposely constructed by the curriculum development staff... My tentative conclusion would be to reject all curricula that are too tight in ... objectives.

At the International Congress on the Improvement of Chemical Education held in Wroclow, Poland, 17 - 22 September 1973, the following recommendations regarding the specification of objectives in chemistry teaching were adopted⁶⁷:

1. All courses in chemistry at all levels should have written statements of aims. These should be known to the teachers and to the students, and the assessment must reflect the aims.
2. For some courses and for some approaches it is necessary to define precise objectives. Even when it does not seem essential, some teachers will find it helpful to define objectives and to make them known to their students. Furthermore in some situations it may be practicable to involve students in defining objectives.
3. Chemistry teachers at secondary and tertiary level need assistance and even instruction in formulating and using aims and objectives. Conferences and courses are needed which concentrate on this problem, and on the problem of achieving the right level of specificity for statements of intent to be translated into meaningful action in the classroom.

Here, too, the need was felt for guidelines as to the levels of specificity of objectives but no recommendation about what this level should be was made.

A similar uncertainty about the precision of objectives was reported at the International Conference in Physics Education held in Edinburgh in 1975:

To assess what a student has achieved requires an understanding of, and certainty about, what a student is expected to achieve. This is not easy or even possible if objectives of teaching a physics course are either non-existent or not clearly stated, as is the case with most physics courses today. Admittedly, ... it is expected that the teacher who handles the course will translate (the) implicit objectives into specific ones for different parts of the programme. This expectation assumes the existence of short term measurable objectives which are correlates of the long term implicit ones.⁶⁸

Those who favour a very high degree of specificity, are usually also in favour of behavioural objectives. These will be discussed in the next section.

3.5.5 The criterion of behavioural expression

This criterion is intimately related to the previous one and may be thought of as the extreme view in favour of highly detailed and specified objectives. The arguments usually offered for and against behavioural objectives have already been outlined in paragraph 2.2.5.

On the topic of behavioural objectives one finds oneself confronting a situation which is not atypical of Education: those in favour represent an extreme position on one side of the issue, and those in opposition represent the extreme opposite end of the spectrum. This may be exemplified by quotes from the literature.

B.F. Skinner⁶⁹, states:

The key step in improving the status of science education is discarding the high sounding but meaningless concepts that we have been relying on to describe what is to be taught and how it is to be learned - such notions as intellectual structure and concept formation - and to emphasize instead concrete, definable behaviours and the processes which can be used to shape and control these behaviours.

In contrast, Alex Johnstone⁷⁰ sounds a warning:

Objectives are now supposed to be couched in clear, operational and unambiguous words. Verbs such as "know", "understand" and "appreciate" are taboo while words such as "recite", "write" and "state" are in. The expected behaviour of the learner must also be described in terms of minimum performance levels necessary to satisfy the assessor.

A statement such as, "The recruit must learn to fire a rifle" just will not do. For the objective connoisseur nothing less than the following will suffice: "The recruit must be able to fire five shots from a Lee Enfield rifle at a two metre target a hundred metre away scoring at least four bulls in twenty-five seconds".

This describes the stance adopted by writers such as Mager. Mager and his followers have now become an "objectives aristocracy" who tend to scorn lower mortals who slip from these criteria of "a good objective".....

We must take care in our thinking about this aim ~~.....~~. It is so possible to get bogged down in this that we can lose sight of the wider implications of an education. Our noses can be pressed so hard against the bark that we cannot see the trees, let alone the forest.

Many authors on the curriculum simply accept behavioural objectives and Bloom's taxonomy uncritically and as a matter of course. This is exemplified by Michaelis et. al.:

A basic step in curriculum planning is the formulation of objectives that are contributory to the attainment of major goals. This may be done by identifying behaviors that students should develop if they are to attain the goal ...

Another basic consideration in moving from goals to objectives involves levels of complexity of learning and internalization of learning. Two taxonomies that are especially helpful in this regard are presented in the following section.⁷¹

(The taxonomies are those of Bloom and Krathwohl.)

This general acceptance is also evident in the Scottish Integrated Science Course⁷² the objectives of which are based on a simplified version of Bloom's taxonomy and by the gymnasium courses for physics and chemistry (Gymnasiale Oberstufe) of Nordrhein-Westfalen.⁷³ In the case of the latter two courses their total content is presented in the form of behavioural objectives. In Britain, too, an effort was made to write detailed behavioural objectives for the last two years of an O-level chemistry course. The committee entrusted with this task produced a list of 450 objectives for the course.⁷⁴ About this exercise Alex Johnstone remarks:

You may well gasp, but this was a serious exercise carried out by fairly sober people who saw this as a valuable thing to do. It is possible to be deafened by the thunder of

objective hobby horses ridden by well-meaning but uncritical educationists. The reader should give much careful thought to this problem before he mounts his hobby horse and joins in.⁷⁵

Not to be outdone, the curriculum designers in Nordrhein-Westfalen, Germany, came up with a list of very nearly 800 objectives for a chemistry course.⁷⁶

At the other end of the spectrum there has arisen an anti-objective reaction, such as that published by Wolke⁷⁷ in the Journal of Chemical Education. On this "anti-objective backlash" Johnstone remarks:

Like all swings, this is probably going too far in its zeal and is in danger of throwing out the advantages of educational objectives in an attempt to escape from the claustrophobia imposed by them.⁷⁸

Clearly, then, between Skinner and Mager on the one hand, and Wolke and Stenhouse on the other, the arguments pro and anti are unresolved.

In an interview the Weizmann Group put their point of view quite clearly: "Our objections are that this type of objective (a) is not applicable to all levels of teaching and not even to all parts of the curriculum, and (b) does not provide for attitudes".⁷⁹ Another practising curriculum group engaged in the development of the PLON materials in the Netherlands expressed similar views.⁸⁰

In the light of the lack of any conclusive evidence and the abundance of contradictory opinions, the definition of objectives in terms of behaviours is rejected as a criterion. Until such time as more evidence becomes available the author proposes that the criterion of precision should be developed along the lines suggested in paragraph 2.2.6.

3.5.6 The criterion of comprehensiveness

The main criticism levelled against the use of highly specified process objectives is that they are limited to the acquisition of knowledge and skills and that the higher abilities and affective and social domains are neglected. This criticism

implies a plea for a more comprehensive range of curriculum objectives. In a paper read at an International Conference on Physics Education⁸¹ it was suggested that objectives for physics courses should be derived from (a) statements of general educational aims directed towards students' formation and understanding of concepts, acquisition of enquiry skills and formation of attitudes, and (b) statements of national and philosophical goals which may possibly influence physics teaching aims.

Comparable statements come from the chemists. Cohen in his paper presented at an International Congress on the Improvement of Chemical Education, states that -

... some of the criticism of current chemistry curricula has been based upon an alleged neglect of objectives concerned with the personal, social, economic and moral implications of chemistry on society. For example, in a position paper prepared for the Curriculum Committee of the American Chemical Society, Cassidy blames over-concern for content for the neglect of communication and of "personal problems of the students in learning the meaning of science and sensing its power to strengthen their lives".⁸²

As in the case of behavioural objectives, this concern for objectives outside the terrain of the cognitive and skill aspects of teaching, has led to an extreme stance favouring education through science as opposed to education in science. Knowledge of physics and chemistry has been relegated to a subordinate role in the curriculum and the emphasis has shifted towards the personal, social, economic and moral issues of science. Thus, a working group of the Edinburgh International Conference on Physics Education declares that

... The human and social aspects of science should be woven into the fabric of all school courses; science must be taught as a human activity which has relevance to the individual in his social, physical and biological environment... It should show the interaction and overlap of scientific developments with social issues.

The teacher should have the freedom to explore controversial issues.⁸³

This expansion of the scope of the curriculum raises new issues. As soon as the science teacher leaves the narrowly scientific curriculum, he has new problems. He is now in a position where he has to present opinions rather than data, in a situation in which what he teaches may be affected by his own subjective judgements, in which objectivity is not possible and in which some views expressed may be unacceptable to some pupils, members and groups in the community or to the school authorities.

Reid⁸⁴ is of the opinion that the statement of objectives is not enough for teaching towards the attainment of attitudes, but that they must be supported by the development of techniques, by the setting of "sympathetic examinations" and, most important of all, by sympathetic teachers. He maintains that the development of attitudes and awareness of economical, social, moral and other related issues, is based on "interactive processes". He identifies three types of interaction, viz. student-material, student-student and student-teacher. The latter he rejects as too difficult to control and pleads for more research and development of materials in the area of student-material interaction. Games, simulations and case studies offer possibilities for such materials. He supports his arguments by quoting research by S.A. Brown and R.H. Haddon which indicates that no differences in pupils' attitudes could be found in pupils offering integrated science with affective objectives and those doing optional pure sciences with academic objectives. Neither were there any differences in attitudes towards science and the issues of science among science pupils and non-science pupils. This is also confirmed by Alexander's evaluation of Nuffield Secondary Science where she states that "It would seem that .. (pupils') attitudes to science and to the relevance of science in society have not improved".⁸⁵

Although there is general agreement that the objectives of school science courses should provide for the affective and social aspects of education, the attainment of these through the use of "ordinary" materials and methods - both traditional and modern -

may be questioned. The inclusion of these objectives requires the selection and design of content, methods and evaluation techniques which make their attainment feasible.

The other major component of the criterion of comprehensiveness refers to the provision for a wide range of abilities and interests. The first of these two, viz. abilities, has become a major issue in Europe and Great Britain as a result of governmental insistence on comprehensive schools and mixed ability intake and teaching as a means of achieving the politically inspired ideals of "offering equal and optimum chances, independent of social setting and the awakening of social consciousness".⁸⁶ The means for achieving the comprehensive ideal are usually (a) to integrate two or more schools; (b) to withdraw governmental subsidies from "selective" schools; (c) to integrate subjects; and (e) through mixed ability grouping of classes. In the field of science, curricula such as "integrated science" and "combined science" are designed to meet the needs of classes of mixed ability and backgrounds.

Practical teaching problems have led to the design of "curriculum packets" based on an encounter model (PLON)⁸⁷, extensive worksheets to replace the usual written materials (Scottish Integrated Science)⁸⁸ and individual learning techniques (Netherlands)⁸⁹. The special problems encountered with pupils of low ability and low motivation gave rise to special curricula such as the LAMP Project.⁹⁰ At present all these activities seem to be mainly concerned with the primary and junior secondary stages of school education although some work is in progress to design courses for the "non-science group" of the senior secondary level.

As is usual, reaction against integrated science has already set in⁹¹ and the educational desirability of such courses and of grouping pupils of a wide range of abilities together have been seriously questioned. The basic question whether it is indeed possible for pupils to derive the optimum benefit from mixed ability teaching is under suspicion.

Pupil interests, too, may be as varied as the number of individuals in a class. Some curriculum workers interviewed view pupil interests as the "current group interests of the adolescent"

but, as was pointed out by others, it would be extremely difficult to relate most of the current group interests to science education.

Whereas it was generally agreed by all those interviewed that curriculum objectives should provide for as wide a range of abilities and interests as possible, the practical implications and difficulties were fully realised. It was suggested that the statement of the criterion should be formulated in such a way that the limitations of its applicability would be included.

3.5.7 The criterion of relevance

The preliminary formulation and explanation of this criterion are based on that of Goodlad and Richter⁹² and refer to the pupils only. Thurber and Collette⁹³ list the criterion of "meaningfulness" and explain it as "Learnings should be meaningful; pupils should want to know". From discussions on the validity of this criterion it was concluded that relevance is an essential condition for the formulation of curriculum objectives and one that has often been neglected in the transfer of curriculum materials from one country and culture to another. This view is supported by Parry:

The educational system is strongly tied to the political, economic, and cultural life of the community. The background, experiences, and expectations of a native tribesman in Africa, or a farmer in Asia, differ markedly from those of a student in a modern, well-equipped urban high school in Continental Europe. The educational approach must reflect these differences in culture... The chemistry of nitrogen may be important to all, but at a different level. In one case control of air pollution may be the technical goal; in the other, control of soil nitrogen may be the important challenge. The basic laws of science are the same, but the place where the laws make contact with the student's life is different.⁹⁴

He cites further examples from a variety of situations which supports the criterion of relevance.

An interesting and unusual aspect of relevance to social and cultural mores emerged during the discussion of this criterion with the Leeds Group. Members from Nigeria pointed out that some of the objectives and methods requiring a critical attitude from pupils, encouraging them not to accept statements but to question them on the basis of the available evidence and logic of the arguments, are not easily applicable in parts of their country. The pupils are brought up not to question statements made by their elders (which would include their teachers) and in some instances they are not even allowed to contribute to or to participate in discussions with their elders.

Relevance to the pupils' environment in the rapidly changing technological world, is simple to illustrate: objectives aimed at how to operate an electronic pocket calculator are more relevant than objectives concerned with operating an abacus. The problem arises with the rapidly changing nature of this environment and the need to prepare pupils for a technology - and its implications - which has not yet been evolved. This already provides a pointer to another criterion, namely that of flexibility.

3.5.8 The criterion of flexibility

Many authors include this criterion for curriculum objectives, although it is very often framed in different terminology. Thus, Thurber and Collette⁹⁵ include a criterion called "timelessness", stating that learnings should be concerned with material familiar at the present time, not with obsolete devices and ideas. Gunter states that

No aim ... should ever be regarded as perfectly rounded off, final and unchangeable .. If the educator really desires that the goal for which he is striving should be active as a dynamic and motivating force in educational practice, it is his duty to review it critically from time to time and to modify and reformulate it in the light of changed circumstances and needs and new knowledge.⁹⁶

Butler⁹⁷ applies the criterion of adaptability without developing it any further than giving an example of "adaptation to local needs". Borger and Seaborne⁹⁸ remark that it is a commonplace that we are living in a rapidly changing environment. "New scientific discoveries and related technological developments are appearing at an ever-increasing rate. It requires constant reconsideration ..., the re-evaluation of objectives .. Knowledge does not simply accumulate, it also becomes obsolete".

In sharp contrast to the views of these authors, the criterion of flexibility, changeability, timelessness or adaptability is absent in the writings of the advocates of behavioural objectives. This may be due to their emphasis on the cognitive and skills aspects of education.

The curriculum workers and educationists with whom this criterion was discussed, agreed with its inclusion. It was felt that the omission of this criterion might lead to extended periods of curriculum stagnation resulting in the kind of upheaval and major change characterised by the post-sputnik revolution in science education. The general consensus of opinion is perhaps best expressed in the words of Johnstone: "There must be a mechanism by which objectives can be modified in the light of experience or new knowledge so that they can be of maximum value to the teacher and learner alike".⁹⁹

3.5.9 The criterion of internal consistency

The criterion of internal consistency and non-contradiction is quoted by many writers such as Goodlad and Richter,¹⁰⁰ Cohen,¹⁰¹ Michelis et. al.¹⁰² and Smith et. al.¹⁰³. Michaelis and his co-authors state that objectives "should be consistent with one another so that they provide a coherent sense of direction at all levels of instruction and across all areas of the curriculum". Cohen discusses at some length the contradiction in objectives that may arise if a single curriculum is devised to meet the needs of both general and specialised education.

Although we again find differences in terminology, such as consistency, non-contradiction, supportiveness and reinforcement, agreement on this criterion is fairly general and unanimous.

In analysing the explanations and detailed discussions of these different formulations, however, slight differences in interpretation can be found.

This same agreement mentioned and the differences in interpretation were also found in discussing this criterion with curriculum workers. It was obvious that a broader interpretation overlaps with the first criterion of convergence. The Weizmann Group seriously questioned the distinction between these two criteria pointing out that internal consistency is inherent in the criterion of convergence.

After further discussion with different curriculum workers it was agreed that the criterion of consistency should be included in that of convergence and that the detailed explanation of this term should clearly indicate the requirements of non-contradiction and supportiveness of objectives.

3.5.10 The criterion of realism and feasibility

The very nearly universal acceptance of this criterion is clearly shown by its high incidence in the various writings. The strongest statements in this respect come from Johnstone where he says:

A second way in which the use of objectives has got out of hand is that committees of planners sitting in isolation from the "chalk-face" have proposed objectives, particularly those in the affective domain, which are an expression of their personal ideals but which are totally unrealistic for pupils of the age or ability or social background in question.

Objectives must never be treated as if they can be logically deduced and as if they were sacrosanct. It may be impossible to attain some objectives because they are unrealistic for the pupils or because there are boundary conditions to school situations such as lack of money or facilities or because teachers and pupils do not heartily subscribe to them.

3.6 The final formulation of criteria for curriculum objectives

From the analyses and arguments outlined in the preceding sections the following eight criteria for the selection and formulation of curriculum objectives were formulated:

1. Convergence

Curriculum objectives should converge into a single focus, namely the ultimate aim of education. This means that the objectives should also be internally consistent, i.e.

- (a) contributory to the attainment of the general curriculum aims;
- (b) internally supportive; and
- (c) non-contradictory.

2. Validity

Curriculum objectives should be valid in the educational, societal, professional and vocational context.

3. Appropriateness

The objectives should be appropriate to the age, maturity, readiness, ability, existing knowledge and understanding of the pupils and to their social, cultural and economic backgrounds.

4. Precision

Curriculum objectives should be formulated with a sufficiently high degree of precision and specificity to provide teacher and pupil with clear direction and guidance regarding the interpretation of content, and the knowledge, skills and attitudes required, and the evaluation of the knowledge, skills and attitudes, but not to such a degree that they constitute a specification of content detail.

5. Comprehensiveness

The objectives should provide for as large a range of abilities, interests and values as is possible within the limitations imposed by the composition of the pupil population, the nature of the subject or subject area and practical feasibility.

6. Relevance

Curriculum objectives should be relevant to the characteristics of the pupils, i.e. to their lives and lifestyles in the cultural, social and technological context.

7. Flexibility

Objectives should be flexible and changeable in order to provide for development in knowledge of the subject, the learner, the learning process, methods of instruction, evaluation and related areas of education, as well as to accommodate changing needs.

8. Realism

Curriculum objectives should be realistic and feasible in the sense that they should be attainable and it should be possible to translate them into practical teaching activities.

3.7 The application of criteria for objectives

The close relationship between objectives and the other elements of the curriculum has already been pointed out. As a result of this relationship and interaction, criteria for objectives should be applied at all stages of the design of the curriculum: the more specific objectives will be affected and determined to a very large extent by the content selected, the methods designed and by aspects of the evaluation. The following procedures, based mainly on discussions with curriculum workers, are suggested:

1. Formulate the major aims and objectives for the curriculum, including those for practical work (laboratory work) and determine their value and acceptability by applying the criteria to them.
2. Formulate the more specific objectives for the content which has been selected. Again apply the criteria to these objectives.
3. Further clarity on the refinement of objectives is obtained from discussions and decisions on how it is intended that these objectives could be attained. The methods available or designed will most probably reflect on many of the criteria, such as appropriateness, realism and others.

4. Similar revisions and refinements of objectives will result from the evaluation and assessment stage. Because of this feedback towards the end of the curriculum cycle, it is essential to have one or more trials of the curriculum materials.

On these two stages Nicholls and Nicholls remark:

They will find that during this step in the process of curriculum development, as they discuss content, materials and method, there will be a further clarification of the objectives, and again, if there is need for still further clarification, this will occur when techniques of assessment are discussed.¹⁰⁵

5. The criteria for objectives should always be applied with proper balance and to achieve optimum effectiveness. Thurber and Collette¹⁰⁶ refer to this balance where they state "Sometimes teachers emphasize one or two of these criteria at the exclusion of others. Care must be taken to avoid this practice for the good of the learner".
6. Finally, the curriculum worker should return to the major aims and objectives formulated initially. It may be necessary to amend, refine and restate them in the light of the feedback obtained during the different stages of curriculum design.

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CHAPTER 7CRITERIA FOR THE SELECTION OF CONTENT

Selecting the content, with the accompanying learning experiences, is one of the two central decisions in curriculum making, and therefore a rational method of going about it is a matter of great concern.

- Hilda Taba¹

1. INTRODUCTION

Decisions about which subjects and activities should be included in the educational programme of a school take precedence over the selection of the content of any single subject or activity. Thus the question: "Why teach science?" is of primary importance and is followed by the equally important question: "Why teach Physical Science?". For the purpose of this dissertation it is accepted that both these questions can be answered in a positive manner, that is, that the inclusion of science, and in particular of Physical Science, can be motivated on the basis of sound educational reasoning, and not simply justified as a subject area that may contribute to the education of the child if taught "correctly and properly".

These questions have been discussed at length and in depth by various authors. White², Hirst³ and Phenix⁴, and Barrow⁵ approach their arguments from different points of view, viz. an analysis of intrinsically worthwhile activities, the nature and classification of knowledge, and a philosophical approach, respectively. They arrive at essentially the same conclusions, albeit for different reasons: natural science is an essential component of a secondary school programme and should form a compulsory part of the curriculum, and the physical sciences, being more fundamental, are preferred to the life sciences.

Perhaps their conclusions are best summarised in the words of Sir Percy Nunn:

.... the true significance of the major school subjects lies in the fact that they represent creative activities of the human spirit which have played an essential part in the race's secular advance from barbarism to civilization, and remain essential factors in the active mind of our own age.⁶

As complex creative activities of the human mind and spirit which are now, and will almost unquestionably be in the future, essential factors in the intellectual life of mankind, physics and chemistry - Physical Science - must indeed qualify as an essential school subject.

Both physics and chemistry cover a vast and complex range of knowledge, and, according to Whitfield⁷ "... it is estimated, for example, that the quantity of scientific and technological knowledge, expressed in terms of hard facts, is doubling at the present time in less than ten years". Obviously then, what can be taught at school level, can only be a very small selection of the content of these subjects. The extremely difficult but important question of what to select cannot be avoided or circumvented, and any model or theory for curriculum design should make an effort to provide "a rational method" for going about the selection of content.

As was stated in Chapter 4, Section 3.5.3, "the argument about the curriculum content cannot be resolved unless clarity about the aims has first been achieved", and it is thus essential to take a brief look at the different aims of science teaching, as well as the claims made for the value of science as a school subject.

2. THE AIMS OF SCIENCE TEACHING

2.1 General aims of science teaching

The literature abounds with lists of, and suggestions for, aims of science teaching. Muller⁸ devotes a lengthy chapter to the analysis of aims derived from reports of commissions, special studies, curricula and science text books. A typical

example of the variety of aims to be found in these lists, is the one compiled by Billing⁹, presented here in simplified form:

1. To develop and sustain an interest in science as a central and challenging area of study.
2. To develop a working knowledge of, and favourable attitude towards, scientific methods of investigation.
3. To encourage the exercise of curiosity and creative imagination, and an appreciation of the role of such speculation in the selection and solution of problems, the construction of hypotheses, and the design of experiments.
4. To develop the ability to see, and the habit of looking for, inter-relationships between individual phenomena, principles, theories, philosophies or problems.
5. To develop an appreciation of scientific criteria and a concern for objectivity and precision.
6. To develop an understanding of the fundamental and unifying principles underlying scientific phenomena, and an ability to apply these principles to real problems involving materials in various physical and biological conditions.
7. To develop the skills, knowledge and habits required for the safe, efficient and responsible manipulation of chemicals and apparatus in common laboratory procedures.
8. To develop confidence and skill in the quantitative formulation of problems and in the treatment of data.
9. To develop in the student the predisposition to think logically, to communicate clearly by written and oral means, and to read critically and with understanding.
10. To promote the student's understanding of the significance of science, technology, economics and sociological factors in modern society, and of the contributions they can make to improve material conditions and to widen man's imaginative horizons and his understanding of the universe.

11. To encourage the applications of scientific knowledge and skills to problems which are of importance to the community, in particular the optimum use of natural resources.
12. To provide an opportunity for the development of the student's motivation and social maturity, including an appreciation of his own limitations in relation to a career choice which will be fruitful to himself and to society.
13. To develop the student's understanding of the structure, values and procedures of science-based industries, and the scientist's professional role in such a situation.
14. To develop knowledge of, and familiarity with the use of, important sources of scientific information.
15. To make the student aware of the limitations of his disciplines and their methods and to provide opportunities for him to understand, make and criticise value judgements.
16. To cope with individual differences in the abilities and interests of students, so as to ensure the optimum development of each student's potentialities for achievement and satisfaction.
17. To draw upon staff interest and expertise in such ways that the teaching is challenging and satisfying.

These aims may all be educationally valuable and worth pursuing, but the majority of them are not unique to science teaching. The "exercise of curiosity", for example, can be encouraged through the medium of other subjects, and so can "the ability and habit to look for inter-relationships", "concern for objectivity", "the predisposition to think logically", and many others. Perhaps one should look at the more particularly "scientific" of the proposed aims, namely those related to the acquisition of scientific knowledge and skills, and the teaching of the so-called "scientific method".

2.2

The acquisition of scientific knowledge as an aim

It sounds reasonable to expect that everybody should have at least some scientific knowledge, and that it is necessary in the world we

live in for people to understand how a motor car works, how to connect an electrical appliance or mend a fuse, to understand something about the transmission and reception of radio and television signals, and to have other knowledge and understanding directly related to everyday life.

Yudkin¹⁰ remarks that it is difficult to imagine "an ignorance more harmless" than that of such matters as how a television receiver or car engine works. Amplifying this remark, Barrow adds:

Does it really matter that at the present time many thousands of people are ignorant of such things? Does it matter to them as individuals or to the community as a whole? I cannot see any reason to suppose that it does. So long as we maintain a supply of specialist technicians, who can mend our televisions and cars for us, it is difficult to see how such ignorance in specific individuals harms the community, harms the individuals concerned.... or affects the quality of life in a community in any way at all.

It is sometimes argued that, in a democracy, many political and social decisions involve scientific knowledge and issues. Therefore, it is said, the electorate should have the knowledge and understanding to make judgements about governmental decisions and policies on such matters. But, as Barrow¹² remarks, the problem is that the level of scientific knowledge required to cope with such questions is beyond the level that we can realistically hope to attain with children.

He adds:

Moreover the information we impart to schoolchildren will in all probability be out of date by the time they come to face such issues in adult life... All in all the sort of scientific facts that we would be likely to impart to children do not seem to be particularly important.¹³

Although Barrow's remarks refer in particular to the first two years of secondary school education - comparable to the South African junior secondary phase - much of his reasoning also applies to the senior secondary phase as now taught. Whatever is included in the senior science curriculum of a school can but be a small selection from the accumulated scientific knowledge and may be as much subject to a decrease in relevance for future application as is the content of a junior course.

2.3 The understanding of scientific method as an aim

It is not always clear exactly what curriculum designers mean when they refer to the understanding of the "scientific method" as an aim of science teaching. Generally the scientific method - if such a clearly definable method exists - is taken to mean the process of observation, hypothesis, empirical testing of predictions, and, sometimes, the refining or recasting of the hypothesis. Very often, though, it would appear as if the "discovery" or "enquiry" methods, which are currently very much in vogue, are equated to the "scientific method".

Let it be assumed that a unique and specific scientific method exists. It is then argued that an educated citizenry should be aware of and conversant with what scientists actually do. This argument, stated in many "modern" curricula, is clearly presented in Curriculum Paper 7 of the Scottish Education Department:

The first cycle of secondary education is the only time during which we can be certain that all pupils in a school study the sciences. The Working Party therefore decided that they should take this opportunity to present to the pupil those aspects of science which would best contribute to his general education. In the integrated syllabus which has been prepared for the first two-year cycle, therefore, there is a much reduced emphasis on the retention of the factual content of the syllabus. Instead an attempt has been made to

expose pupils to many other aspects of the work of the scientist; the apparatus at his disposal, the experimental methods he uses, the different processes of thought by which he arrives at his conclusions and the language which he uses to communicate these conclusions to others. For the group of pupils with whom we are concerned in the second cycle of education we feel that such an intent is equally suitable.¹⁴

One even finds similar statements in books on the teaching of elementary (primary) science, such as those by Blough and Schwartz¹⁵ and Victor¹⁶. The latter states, without proper motivation, that

Learning the key operations of science and the scientist is a vital objective of elementary science. As an objective it has more than one goal. When children learn the process of science, they gain insight and practice in the different methods that scientists use to solve problems. They also become familiar with effective ways of working, and they acquire experience in thinking critically and creatively. As a result, the children can develop valuable scientific behaviors. Furthermore, the key operations of science and the scientist can be used to solve problems in other areas of the elementary school curriculum, and even in daily life as well... Science is also a process of inquiry that should govern our behavior at all times.¹⁷

Yudkin¹⁸ carries the argument to extremes where he states that scientifically literate men will appreciate the activity of the scientist as a blend of creativity and vigorous intelligence: "Science will no longer appear as a mysterious force, uniquely powerful and slightly sinister. Scientific literacy is necessary so that man may no longer be controlled by science, but may be restored to his position as controller".

Apart from perhaps the impact on a primitive and superstitious person meeting some of the more dramatic products or effects of science for the first time, there is no evidence that a scientifically "illiterate" person in a civilized community lives in fear of science as something sinister that is controlling man. This argument belongs to the realm of science fiction. Nor are there self-evident reasons requiring people to appreciate the true nature of the activity of the research scientist. The arguments offered for this may just as well apply to the requirement that one should be able to appreciate the true nature of the activities of the historian or educationist, or of any other subject specialist.

Finally, as Barrow¹⁹ points out, "examination of the true nature of scientific reasoning and of the status of the findings of inductive reasoning in science is essentially an epistemological question belonging to the sphere of philosophy", and may well be catered for elsewhere in the educational programme.

2.4 Why teach science?

According to the first criterion formulated for curriculum objectives these aims should contribute towards the ultimate educational aim, or, in the words of Tricker²⁰ "the more fundamental objective needs to be emphasised". This most fundamental aim is the survival of Man. Paul deHart Hurd puts it as follows:

Our primary goal in education is to develop individuals with the capacity to meet and survive change. Curriculum decisions need to be made in the same context....

As the role of science in human affairs continues to increase in importance, science becomes central to general education.²¹

This is echoed by Quattlebaum in another context:

Our development of more and better trained scientific engineering and other professional manpower is important to our national survival. It is fundamentally an educational problem...²²

Thus,

We want scientists...; conversely we do not want to commit people to the study of science who do not find it suits them. The conclusion is obvious: all children should be initiated into science for a period of time that is sufficient to give them a clear idea of what studying science really involves. This will ensure, in so far as it is possible to ensure anything, that everybody is in a position to make a reasoned choice as to whether he wishes to pursue this important activity.²³

With this conclusion of Barrow the author agrees, but from a completely different point of view. Barrow's fundamental aim is that of the happiness of man in terms of the extent (the number of people affected), intensity, duration and fecundity of the pleasure man derives from life. According to him "science is a complex business, a business that may afford great pleasure to the individual concerned with it, and a business of great value to the community, judged from the standpoint of pleasure.... Ideally we want all people who would enjoy being scientists to be scientists..."²⁴ The author's point of view is that this reasoning, based on Jeremy Bentham's utilitarianism, arrives at the correct answer for the wrong reasons. Science must be taught to all children at school in order ^{that they may} be able to make "a reasoned choice" because the survival of Man demands it, and not only because of the pleasure it could provide to individuals and to the community.

All other aims are secondary. In making this statement it is not implied in any way that the other proposed objectives and aims could not be educationally valuable or valid, but only that they are not fundamental. Those other aims, if they conform to the criteria, are by way of being educational bonuses and do not provide the essential reasons for the inclusion of science in the programme of the school.

From these arguments it follows logically that, in order to give children "a clear idea of what studying science really involves", what should be studied at school should be the subject "science" and not something which is called science but merely provides the medium for "inculcating intellectual skills, mental attitudes and ideals".²⁵ This is also clearly implied by Helm where he states:

Clearly... one still has to teach a subject; and it will remain important, we suggest, that the subject-matter should be taught in a way which respects the fundamentals of the subject, as well as being in accordance with.. "sound educational theory".

The generally agreed objectives of the teaching of physics (or of any science subject) are the attainment by the pupil of knowledge and understanding of the subject and the ability to learn more of it.²⁶

The opposite point of view may be represented by the arguments put forward by Richmond in The School Curriculum:

As regards the teaching of science, the doubts (about the teaching of science as an area of knowledge) go deeper than this, not merely because the problem of deciding what to include and what to leave out of courses is aggravated by the heady growth of information, but mainly because of the recognition that the findings of science, once held to be "positive knowledge", are so hedged about with uncertainty as to be, at best, provisional. This explains why in all recent science teaching projects there has been a marked shift away from methods of teaching which rely on memorization of factual details and the acceptance of data as given in favour of a more

open-ended approach which allows the learner to experience the nature of scientific inquiry for himself... Whichever way we turn, we find this same transfer of the focus of attention from the content of learning to its situational and contextual aspects...

Dwelling on subject-matter is inexcusable for a variety of reasons...²⁷

Of this variety of reasons, Richmond provides only two:

- (1) He rejects the assumption that the subject matter is worth knowing for its own sake, stating that it is not worth knowing unless it can be put to practical use and that it may be no more than a medium for inculcating intellectual skills, attitudes and ideals.
- (2) Concentration on subject matter places too heavy a workload on the learner, because the number of topics judged to be worthwhile or essential are necessarily too many.

He advocates a shift from content-oriented to pupil-oriented teaching and quotes Jevons in support:

Student-oriented teaching must concentrate not on what the course covers but on what it does to students; that is, it must attend less to what is taught than to how it is taught. If that could be effectively achieved, the clutter would almost automatically drop out. A student-oriented overloaded teaching programme is a contradiction in terms. If it is successfully student-oriented it cannot be overloaded.²⁸

Richmond's arguments have already been countered by those presented in the first part of this discussion, and vice versa. Obviously these types of arguments are based mainly on the different authors' personal approach to science education and on their particular philosophies of life. Simply collecting arguments pro and con does not settle the issue but merely serves to point out and underline the differences.

The author's point of view is reflected by the first set of arguments and is based not on, what Taba calls, "temporary needs, feelings of urgency, and educational fashion" but on a commitment to "the survival of Man as a uniquely human being" as a basic premise. While all the various claims made for the educational value of science as a school subject are not rejected, these claims do not form the primary, or even main, reasons for the inclusion of the physical sciences in the school programme. Neither should these claims solely determine the selection of content, since such a procedure very often leads to a product bearing only a superficial resemblance to the subject as such. Tricker²⁹ summarises this very well in stating: "There need be no transfer of the lessons learnt in science to other fields of thought. Its own field is sufficiently important to provide a thorough justification of its inclusion in the curriculum".

3. CRITERIA FOR THE SELECTION OF CONTENT

3.1 Introduction

As a consequence of failing to distinguish between curriculum content and teaching-learning experiences among some curriculum workers and writers, criteria presented under both these headings will be discussed in this section. Those relating to teaching-learning experiences will, however, be scrutinised carefully in order to separate the criteria for content from the criteria for method.

3.2 Criteria derived from an analysis of curricula

Cataloguing the content of a curriculum is a fairly simple operation, but to deduce the reasoning behind the particular selection of topics is an extremely difficult task and one that may degenerate into pure conjecture. Although the curriculum designers may have applied many other criteria than those listed below, an effort was made to limit the extraction of criteria from the published materials to those which are clearly stated or obvious from their context:

3.2.1 The Nuffield Science Teaching Project

1. The content was selected in such a way as to minimise rote learning of formal statements and factual content as well as the solving of mechanical problems.³⁰
2. The content should be of such a nature that it would be of value to the pupils "a dozen years later when they are out in the world".³¹
3. The material selected should provide optimum opportunities for pupils to experiment on their own.³² It should lend itself to presentation by the heuristic method as pioneered by H.E. Armstrong at the turn of the century.³³
4. The content should lend itself to the development of conceptual models based on evidence gathered by the pupils themselves by observation and experimentation.³⁴
5. The content should meet the requirements of the external examinations, in this case, the "O- and A-level" examinations.³⁵ (This requirement later lost some of its value with the introduction of special "Nuffield based" examination papers set by the major examining boards.)

3.2.2 The PSSC Physics Course³⁶

1. The content should develop from the simple to the complex.
2. The content should reflect the logical structure and unity of the subject.
3. The content should provide optimal opportunities for pupil experimentation, using simple, or simplified, equipment in order to shift the emphasis away from the authority of the textbook towards scientific inquiry.
4. The content is selected and planned to lead towards an understanding and application of pure logic in the interpretation of experimental results and of observations, and the resulting application of hypotheses and models.

5. The content should provide opportunities for the student to become acquainted with man's intellectual heritage regarding the nature of the physical universe and to attain some understanding of how this knowledge has been obtained.
6. The content has been specially selected in order to develop certain desirable attitudes and an understanding and appreciation of certain ideas, e.g. the construction and application of theoretical models, the confirmation of hypotheses through experiment, the use of logical reasoning, the importance of the mutual interdependence of reasoning and imagination, an appreciation of the role of mathematics in physics, etc.

3.2.3 Project Physics

In this case the selection of content was based mainly on two aims, namely, "to provide a humanistically oriented physics course" and "to attract more students to the study of introductory physics".³⁷ To attain these objectives the content was selected and arranged in order to have the following effect:

1. To help students increase their knowledge of the physical world by concentrating on ideas that characterize physics as a science at its best, rather than concentrating on isolated bits of information.
2. To help students see physics as the wonderfully many-sided human activity that it really is. This means presenting the subject in historical and cultural perspective, and showing that the ideas of physics have a tradition as well as ways of evolutionary adaptation and change.
3. To increase the opportunity for each student to have immediately rewarding experiences in science even while gaining the knowledge and skill that will be useful in the long run.
4. To make it possible for teachers to adapt the course to the wide range of interests and abilities of their students.

5. To take into account the importance of the teacher in the educational process, and the vast spectrum of teaching situations that prevail.³⁸

3.2.4 The Chemical Bond Approach³⁹

Although this course is based on some of the criteria already mentioned in 3.2.1 to 3.2.3 above, its main and (at that time) novel contribution lies in the criterion of selecting the content around a central unifying theme, the chemical bond. It is interesting to note that a similar approach was proposed independently by Van Rensburg in 1958.⁴⁰

3.2.5 The Chemical Education Material Study (CHEMS) Course⁴¹

In addition to the remarkable similarities in approach and rationale to the Nuffield Chemistry Scheme, the designers of the CHEM Study course also emphasise the following:

1. The content reflects a shift in emphasis from descriptive content toward chemical principles.
2. Outmoded material is avoided.
3. The content is selected in order to show clearly, with the minimum of exceptions, the relationship between experiment and theory.
4. The content is selected to reveal the logical development of concepts and the logical structure of chemistry.
5. The course content should contribute toward making the students aware "of the significance and capabilities of scientific activities that will help future citizens assess calmly and wisely the growing impact of technological advances on his social environment".
6. The content is selected to provide for closer continuity of subject matter between high school and modern first year university courses.

3.2.6 Other curricula for physics and chemistry

In addition to those curricula analysed above, the curricula for physics and chemistry of Nordrhein-Westfalen (Germany) and of the Scottish Certificate of Education Examination Board (Ordinary and Higher Grades) were compared with those from the United States and England. Apart from a more "conservative" and "academic" selection and arrangement of content, no additional criteria could be isolated.

Although they were concerned with the teaching of science for general education at the junior secondary level, the criteria for the selection of topics formulated by the developers of the Australian Science Education Project (ASEP)⁴² may provide some other perspectives in this regard:

Criterion 1: The ideas included should lead students to generalizations which enable them to see relationships that they may not otherwise have noticed.

Criterion 2: The ideas should be meaningful to students in that they are related to direct experiences.

Criterion 3: The ideas and the ways of conveying them should be interesting and enjoyable to students.

Criterion 4: The activities of students should contribute to the development of skills and abilities considered desirable.

Criterion 5: ... Precedence should be given to topics in which ideas considered to be more useful or important are developed.

Criterion 6: Most of the ideas included should be dealt with through student activity...

Criterion 7: Simple, readily available equipment and experimental situations are used where possible.

Criterion 8: The ideas, activities and procedures involved are feasible."

Note that criteria 4, 6, 7 and 8 also refer to the design of the teaching-learning activities and not to the selection of topics only.

3.3 Criteria derived from the educational literature

The obvious similarities in the criteria proposed by the majority of educationists - especially those of American origin - can be traced to the influence of Hilda Taba's Curriculum Development - Theory and Practice (1962). It would thus be a fruitless exercise to list all the criteria obtained from the literature consulted. Instead a selection, covering all the criteria that could be identified, is presented here. Even this procedure produces some duplication.

3.3.1 Criteria formulated by the phenomenologists

Gunter⁴³ lists the following four criteria for the selection of content:

1. "Among the various norms and criteria... the chosen educational goal (or goals) is the most important. For the selected subject-matter or content of the various subjects is the means of teaching and, as such, it serves to attain the aim of teaching."
2. "A second important criterion is the particular character and needs of the country or nation in question, with its individual culture, spiritual treasures, traditions and modes of expression in the intellectual, moral, religious, social, political and economic spheres, together with the particular demands of the time."
3. The third criterion is the child himself. The subject matter should be selected by taking into account "the nature and needs of the child as a human being in general; the child as a unique individual having his own particular nature, abilities and aptitudes; the child at his specific stage of development on his way to adulthood with his corresponding abilities, characteristics, experience and needs; and finally, the sex of the child".

4. Finally, Gunter states that it "is possible to reduce all the pedagogic criteria by which a curriculum... should be evaluated to two fundamental norms..." These are: "reality as it is" and "reality as it ought to become in the life of the child". These expressions, typical of the language of fundamental pedagogics, are explained in terms of the expressions of "the child as he is", and "the child as he ought to become" respectively.

Aarts⁴⁴ and Van der Stoep and Van der Stoep⁴⁵ present four identical principles that determine the selection of content. Aarts states: "The selection of subject-matter is not carried out arbitrarily, but takes place according to a few criteria".⁴⁶ These criteria, called "underlying principles" by these authors, are the following:

1. The formal principle, which takes into account the multiplicity of human "functions and powers" ("functies en krachten") and their interrelationships. This principle thus refers to the formative value of the content (compare, e.g., the age-old question of the formative value of the study of mathematics and the classics).
2. The material principle, which is based on the subject-matter as a cultural matter and the school as the life-world of the child, refers to the intrinsically valuable aspects of the content, i.e. that content which presents the child with the natural, cultural and spiritual aspects of his life-world.
3. The social principle, derived from the point of view that the content should have a "supra-individual" component in order to maintain the continuity of social life and to prepare pupils for their future lives in society.
4. The psychological principle. This principle provides for the child as a developing personality.

These criteria and principles, even when stripped of the cumbersome terminology of the phenomenologists, seem to be theoretical generalisations which are of little help and practical value to the curriculum designer.

3.3.2 Criteria derived from authors on curriculum design

D.K. Wheeler,⁴⁷ a British author, lists criteria for content and for "learning experiences". His criteria for the selection and design of learning experiences are the following:

1. Validity, in so far as the experience brings about the behavioural change specified in an objective.
2. Comprehensiveness, or scope: all objectives should have corresponding experiences.
3. Variety of experiences to provide for the heterogeneity of the pupil-audience.
4. Suitability as to the levels of development of the group and individuals.
5. Pattern. "Aims are interrelated, thus so must experiences be interrelated to form a pattern." He refers to patterns of balance, continuity, practical continuity, cumulation, repetition of experiences and multiple learning.
6. Relevance to life.
7. Pupil participation in planning.

He gives the following six criteria for the selection of content:

1. Validity.
2. Significance.
3. Needs and interests of the learners.
4. Utility.
5. Learnability.
6. Consistency with social realities.

Margenau⁴⁸ suggests the following criteria, which may have different levels of importance according to whether students are at primary, secondary or tertiary levels of education:

1. Conciseness;
2. internal consistency;
3. universal applicability;
4. interrelationship within a logically-related network of concepts.

Hurd⁴⁹ favours the following criteria, based on the procedure followed by the CHEM Study writing team:

1. Fundamental importance. (Is the component of the content so important that the curriculum is incomplete without it?)
2. Comprehensibility. (Can the component be developed honestly at a level comprehensible to the students?)
3. Suitability to the nature of the discipline. (Can it be developed out of experimental evidence the pupils can gather, or, at least, understand?)
4. Correlation. (Does it tie in with other parts of the curriculum so that its use will be reinforced by practice?)

As a final example the criteria suggested by Taba⁵⁰ will be presented in some detail. In order to relate her criteria more closely to the content of Physical Science, use will be made of Searles' formulation of Taba's criteria in terms of examples drawn from the sciences.⁵¹

1. The content of a science curriculum should be valid and significant to the extent that it reflects the contemporary scientific knowledge of the disciplines, e.g. rapidly changing knowledge makes some knowledge obsolete, such as the replacing of oxygen by carbon-12 as the standard for relative atomic mass.
2. The more fundamental the knowledge of the discipline is, the greater will be its breadth of application and provision for the acquisition of new knowledge. Concepts that are fundamental to particular disciplines are those which include other ideas, have greater explanatory powers than others, and have potential to generate new knowledge.

Example: In physical science, the molecular theory of matter is more basic than Boyle's Law because it has greater explanatory

power, it serves as a prerequisite for understanding more complex content and can be applied in the explanation of more phenomena.

3. Curriculum content should maintain a relevant connection with the social and cultural aspects of the student's environment; it should be useful to the learner in his everyday encounter with life, e.g. knowledge of the conductivity of substances may be applied in precautions against electrical shocks at home and in the workshop.
4. Curriculum content should represent an appropriate balance of breadth and depth. Breadth is concerned with content, both discipline content and informal, and depth is concerned with the treatment of the content of each area. Example: Knowledge of energy (discipline content) can be associated with consumer products from foods to household appliances (informal content), and the manner in which the discipline content is related to the informal may range from the simple (recall of applications) to the complex.
5. In a logical organization of curriculum content, concepts are organized rationally so that one concept follows from another and leads to yet others in a mutually supporting manner. Example: The content in biology frequently begins with one-celled organisms, then proceeds through simple, multi-cellular organisms to, eventually, complex human physiology.
6. The content of a curriculum become significant to the extent that the pursuit of its knowledge by the students conveys the methods of the investigative procedures employed in the discipline, e.g. the students determine the density of various materials using experimental procedures common to the discipline.

3.4

The list of preliminary criteria for selection of content

The list of unrefined criteria for content, drawn up to serve as a basis for discussion, was compiled from the sources mentioned above,

as well as from other works. Among the latter, Muller's⁵² discussion of the different requirements which the content has to meet, is perhaps worth mentioning. According to him the content should comply with (a) the philosophical requirements, (b) the pedagogical requirements, comprising the biological, the physiological, the psychological, the sociological, the ethical and the aesthetical pedagogical requirements; (c) the psychological requirements, comprising the interest aspect, the level of development of the pupil, the functional nature of the content, the purpose in the content, emphasis on interrelationships among the different parts of the content, individual differences among pupils, the balance of depth and breadth and the ability to provide transfer of learning; (d) general requirements, such as agreement among curricula, agreement among textbooks, the results of experiments and research, the emphasis on only certain content by examiners and the requirements of universities. It would seem as if Muller's list of requirements is more of a scheme of classification than a list of practical criteria and that presentation (method) is sometimes confused with subject-matter (content). In addition, some of his general requirements are of doubtful value since they may be subject to strong non-educational pressures. The majority of his other requirements are included, in some form or another, in the list of preliminary criteria.

Criterion 1. Validity: (a) The content should be valid in the sense that it is appropriate to, and should lend itself to, the attainment of the aims of the curriculum.

(b) The content should be valid in the sense that it is authentic and true, representing up-to-date knowledge that is not obsolete.

Criterion 2. Significance: (a) It should be significant in the sense of being meaningful content, emphasising the understanding of principles rather than unrelated or excessive facts.

(b) The content should be significant in so far as it conveys the methods of the investigative procedures of the discipline.

- Criterion 3. Balance: The content should represent an appropriate balance of breadth of coverage and depth of presentation and understanding.
("Appropriate balance" also refers to the relative emphasis on formal discipline content and informal content, as well as to variations and inconsistencies in balance of breadth and depth in the total curriculum content.)
- Criterion 4. Relevance: The content should be relevant to life, in particular to the life of the pupil, i.e., to his social and cultural environment.
- Criterion 5. Interest: The content should take into account and provide for pupil interest.
- Criterion 6. Learnability: The content must be available in forms which are appropriate to the abilities of the pupils in order for them to master and understand the subject and the subject-matter.
- Criterion 7. Fundamentality: The more fundamental the content is, the greater will be its breadth of application and provision for the acquisition of new knowledge (Taba).
- Criterion 8. Consistency: The content should be internally consistent, and non-contradictory, concepts should form a developmental hierarchy and be mutually supportive, and the different parts of the content should correlate as far as possible with each other.
- Criterion 9. Disciplinary structure: The content should be a representative sample or samples reflecting the structure of the discipline or subject. "The structure of knowledge" as the criterion for content selection "simplifies information, generates new proportions, and increases the manipulability of a body of knowledge" (Bruner).

Criterion 10. Examination requirements: The content should meet the requirements of examinations set for, and selection procedures applied to the pupils.

3.5 The refinement of the criteria

The refinement of the criteria was carried out along the same lines as those explained in Chapter 6, Section 3.5, with the difference that another criterion, not originally included, was suggested by the Weizmann Group during the course of the discussions which the author had with members of this group.

3.5.1 The criterion of validity

In addition to those sources already cited, the criterion of validity is further mentioned or implied by a number of different authors. Nicholls and Nicholls⁵³ formulate it as follows:

It is important that content should meet the criterion of validity. Content is valid when it is authentic or true. At a time of rapidly increasing knowledge subject-matter used in school can quickly become obsolete. It may be facts that are obsolete but it might also be concepts, principles or theories. This problem exists at many levels in schools...

There is another aspect of validity, which applies to method as well as to content. This is that the content (or method) is valid if it is possible for the objectives to be achieved through its use.

Michaelis et. al.⁵⁴ include in their list of nine criteria one called "reliability, authoritativeness, validity and up-to-dateness".

In discussions general agreement emerged that the content of a school subject should be a valid reflection of the discipline or disciplines from which it is derived, assuming that, in the words of Kerr,⁵⁵ "the knowledge component of the curriculum is synthesized from the disciplines". But this assumption was not always agreed with, and many interviewees, especially of the Leeds Group, maintained that school science is mainly a vehicle for general education and

should not be discipline-based, agreeing, however, that that content which is selected because of its particular suitability as a vehicle for general education, should be valid in terms of truth, authenticity and up-to-dateness.

The other aspect of validity, namely that the content should be appropriate to, and lend itself to the attainment of the aims of the curriculum, was usually accepted with very little argument. The Weizmann Group, however, stated that "the aims cannot always determine the content of science, but some content should be taught in such a way as to aid in achieving the aims".⁵⁶ From the literature one finds complete agreement with this criterion. Usually this is also listed first, and is perhaps, therefore, viewed as the most important of all criteria. Gunter⁵⁷ categorically states that this is so: "Among the various norms or criteria... the chosen educational goal (or goals) is the most important".

This criterion also agrees with the reasoning presented in the earlier discussions of the aims of education and the reason for including physical science in the curriculum: if we want to give children a clear idea of what studying science actually involves in order for them to make a reasoned choice, it is because we need scientists for our survival. Unless the science presented to the pupil is authentic and true, within the limitations of our present knowledge and their abilities, we do not present them with a true picture of what studying science actually involves and cannot therefore achieve our primary aim.

This criterion is thus accepted without any change.

3.5.2 The criterion of significance

This criterion also has two aspects: (a) the content itself should be meaningful and (b) the content should convey the investigative procedures employed in the discipline or disciplines from which the subject is derived.

In this regard Kerr⁵⁸ makes the following statement:

The disciplines are the raw material by means of which we expect to achieve our stated objectives. They are the resource from which appropriate experiences arise for the education of children and adults. One of the most significant contemporary developments in curriculum study at school level has been the re-examination of the disciplines as sources for learning. More attention is being given in curriculum building to the basic concepts and methods of inquiry which are used by scientists, by mathematicians, by historians and so on. Our understanding of knowledge depends on the concepts we invent, such as force in physics, the bond in chemistry...; and the broader organizing principles that we find...

Similar views are expressed by Nicholls and Nicholls.⁵⁹ They state that schools have frequently been concerned that pupils should learn large bodies of facts, but that facts are the least significant or meaningful aspects of school subjects and are only important in so far as they contribute to basic ideas, concepts and principles. According to them, study should be based on a number of carefully selected principles, concepts or ideas, and that facts should only be learned to illustrate these principles and concepts. Their inclusion is not warranted on any other basis.

Similar views can be found in the vast majority of modern educational publications as well as in the preambles to most of the so-called "progressive" science curricula. Statements of this kind are so often repeated in the literature that they seem to have achieved the status of an education axiom, in spite of the fact that the arguments presented are mostly statements of opinion rather than of reason.⁶⁰

Only occasionally does one find a point of view which allows for the importance of the learning of facts. At a headmasters' conference W.E.K. Anderson⁶¹ stated that the learning of facts had had a bad press. Facts for their own sake were sterile, but that facts for informed discussion and intelligent judgements were quite different. "It is that, without a knowledge of the facts, opinions and arguments are worthless".

There is a danger that the classification of the learning of facts in the category of "traditional curricula" may lead to the type of curriculum in which factual knowledge is consciously excluded to such an extent that the efforts to provide "meaningful learning of principles, ideas and concepts" produce only a shallow and poor image of what the principle really involves. Elsworth and Pay⁶² call this "teaching a child grammar before vocabulary". Basing their arguments on a quantitative assessment of the knowledge and understanding of basic chemical concepts and laboratory skills of first year university students, they state:

There are two areas which we have felt need attention. In one, we observe that such knowledge of chemistry as students have, is increasingly abstract... Their knowledge of the chemical properties and reactions of the more common elements and their compounds is slight, and some of these compounds are generally quoted as examples of the more sophisticated concepts that have no physical meaning... A well-founded knowledge of descriptive inorganic chemistry is the basis of even modern chemistry...

They conclude that, because of this lack of fundamental knowledge, the average pupil not only loses sight of the goal of chemistry, but probably loses interest in chemistry as such, because the subject becomes increasingly meaningless to the pupil.

One is thus faced with two more or less opposing schools of thought: the one states that the content can only be significant and meaningful if the emphasis is on the teaching of principles and concepts, and the other that a lack of factual background makes the teaching of concepts and principles meaningless. Unless clarity about this issue can be obtained, this aspect of the criterion of significance of subject-matter becomes a useless statement which is open to the variety of interpretations based on the personal preferences of the curriculum designers involved.

The search for answers to this question may be approached from different angles: One may, like Richmond, "take the learners' interest: as starting point" and base the curriculum nearly in its entirety on what the pupils want, like and enjoy and can find out for themselves through self-activity experiences. Alternatively one may, at the other extreme, base one's ideas of meaningfulness and significance of subject matter on the structure of the discipline. Neither of these two approaches seems to be logically and educationally justifiable as the approach to produce a significant and meaningful curriculum content. When one exposes the child to physical science, one has, at least, to teach some physics and chemistry. The type and quality of physical science a child may (or may not) learn through experience based on interest alone is obviously suspect and not what is required in order to make a "reasoned choice" about the future pursuit of science. On the other hand, a curriculum based on the pure, logical structure of the discipline, is too academic and unrelated to the child's ability, experience and interests.

It is suggested that the significance of content is closely related to the psychological processes of learning the particular subjects. Although, as has been pointed out earlier, we do not as yet have available a satisfactory theory of learning, experimental results provide fairly clear clues on concept development in physics matching the subject matter structure, and thus providing for meaningful learning.⁶³ Concept relations in chemistry provide more difficulties. "So far, we can only state that common chemical concepts generally will be of higher complexity than physics concepts since object-phenomena relations in chemistry are more intricate".⁶⁴ Evidence also exists to indicate that the conceptual structure of chemistry as seen by the subject specialist does not necessarily represent the best framework for the acquisition of chemical understanding, ideas and concepts by the student. This is amply borne out by the limited success of the highly structured Chemical Bond Approach curriculum. In this respect Hofacker states:

Connexions and relationships between sophisticated chemical ideas recognized by the mature chemist are not infrequently beyond the student's ability because they are inappropriate to his intellectual and maturational level. It is therefore important to re-examine the conceptual structure of chemistry in an attempt to evolve conceptual schemes whose intellectual requirements match, and are compatible with, the intellectual capabilities of the maturing student.⁶⁵

In simplistic terms, then, the physics component of a physical science course can more easily be made meaningful to the pupil because the logical structure of the subject can be fairly easily matched to the conceptual development of the pupil. In addition, a very large number of physical phenomena can be illustrated, and so made interesting, because these phenomena and their applications can be demonstrated directly and concretely on a macroscopic scale. The major chemical concepts, on the whole, are more complex and are built on fundamental concepts originating in physics, and on more complex basic concepts, such as chemical species, reaction mechanism, structure, conformation and stoichiometry. A curriculum based on a rigid disciplinary structure of chemistry will, therefore, involve concepts beyond the ability of the majority of school pupils. To this must be added that the understanding of most of the chemical concepts is dependent on an understanding of behaviour of matter on the molecular level. This behaviour cannot be directly observed by the pupil, but only as the total and combined effects of molecular behaviour which produce certain observable chemical changes. To overcome this, the teaching is usually based on the use of "models". While the model character, with all its shortcomings due to simplification, may be evident to the qualified teacher, the model is usually interpreted by the pupil as "the real thing" because of his stage of intellectual development and understanding.

Although the above conclusions are indicated by research findings, they are by no means conclusive. They do, however, provide

guidelines towards the selection of meaningful content and can help the curriculum designer to avoid the inclusion of concepts and principles which are too abstract or complex, both in physics and in chemistry. Even so, the major topics selected may not be meaningful to the student unless the factual knowledge required for the structuring of the concepts, is not first acquired. And this cannot be left to chance discovery through pupil self-activity, but should be purposefully taught.

The second aspect of the criterion of significance states that the content should convey "the methods of the investigative procedures of the discipline". This aspect, too, has been emphasised to such an extent in "modern" curricula, that the school-leaver may think that the scientist obtains all his knowledge - even of the most simple and elementary nature - by experiment. Obviously, this is not true. The author has discussed this at length in another context:

If the structure of physical science is to reflect the nature of science and the way scientists work, one should start with the aims of real scientific experimentation. Briefly, these aims are: (i) to obtain new information and knowledge; (ii) to verify and test predictions; (iii) to test the validity of the assertions and claims of other investigators.

Despite the variety of techniques and the differences in methods of investigation applied in the various branches of the natural sciences, one common aim of importance emerges, viz. the acquisition or gathering of new knowledge.

All the information that a pupil can gain from experiments is also available from other sources, and experimentation is therefore not essential for obtaining information. Further, the acquisition of knowledge by this means may create a false impression of the scientist as a person who obtains all required data and knowledge by experiment. Scientists only obtain new information by this method.⁶⁶

This irrefutable fact is countered by the arguments that, to the child, all knowledge at school level is "new knowledge", that discovery through experiment enhances concept formation, that learning by discovery has an inherent motivational value not found in any other teaching method, and that practical work is an essential part of the structure of science. What is overlooked is that the argument is not against practical work, per se, but rather against the unproven claims made for the value of discovery through experiment. No conclusive evidence has yet been produced that practical discovery methods aid concept formation, but instances of the opposite taking place - that it may actually lead to the formation of wrong concepts - have been cited.⁶⁷ That practical work per se creates pupil interest in science is not disputed, but as Ormerod⁶⁸ points out, this is not unique to discovery methods:

There is also long-standing evidence that pupils regard practical work as one of the major attractions of science and did so, even when engaged in routine exercises such as "proving" laws and doing quantitative analysis.

It is against the background of these discussions that the points of view of the educationists and curriculum workers interviewed, should be judged. Apart from the contribution of the Weizmann Group, which is summarised below, no new thoughts emerged from discussions with the Leeds Group or with the tutors and lecturers at Leeds and Dundee.

The Weizmann Group accepted the criterion as formulated, but with some reservations. Firstly, they maintained that the nature of a science subject should not be changed or adapted in order to provide simplified, meaningful concepts or principles suitable for the level of the pupils. Should a concept or principle be too complex or difficult for a particular stage or level of education, it should rather be omitted or postponed to a later age level, or if such knowledge was known to be essential for the development of other suitable concepts, the information should simply be given to the pupils without any effort at explanation.

Secondly, the teaching of, and practice in, the investigative procedures typical of the subject should be limited to those topics in the curriculum which lend themselves to such an approach, and investigations should not be artificially designed and forced on the curriculum. Investigative procedures and techniques should not dictate the selection and structure of the content but should be included only where the opportunity presents itself in a natural and unsynthetic manner.

Responses from the Leeds Group and their tutors, both in Leeds and Dundee, favoured the "progressive" interpretation of this criterion. With a few exceptions, comprising a very small minority of the course members and tutors, the general feeling was that the content of a curriculum becomes more significant by integrating physics, chemistry and biology instead of teaching them as separate subjects, by putting greater emphasis on pupil experimentation and discovery methods, and by selecting and structuring the content to educate through science rather than in science.

The criterion of significance, as formulated, is therefore open to various interpretations and, if it is to be of any real guidance to the curriculum designer, should be reformulated to define its meaning clearly.

The author proposes that one should interpret this criterion against the background of the suggested curriculum model. Content forms part of the activity range and is thus also subject to different activity levels. Science subjects are taught to the young child at pre-primary, primary and junior secondary levels as a means of introducing him to nature, i.e. the natural world in which he has to live and in which he has to survive. The emphasis should thus be on the creation of interest in and an awareness of the wonders of nature. At this activity level the content should be based on the concrete and familiar aspects of nature, employing those methods which in themselves create interest, such as the various activity methods available to the teacher. At the senior secondary level, however, education through science, as opposed to education in science, can only be justified if science as a subject proves itself

to be a better vehicle for this type of education than any other school subject available or yet to be designed. To use science as a subject to serve two masters, namely (a) to create an interest in things scientific and to inculcate an awareness and understanding of the social and practical implications of the effects of science and of technology on the one hand, and (b) to introduce children to the nature of science as a discipline on the other hand, requires a curriculum with different, and possibly contradictory, major aims. The very real possibility that these aims cannot be effectively attained through one single curriculum suggests the introduction of another school subject (Barrow proposes philosophy) at the senior secondary level. It should be remembered that Physical Science at this activity level is included in the school programme to enable pupils to make a reasoned choice about their future pursuit of science. This does not mean or imply that other desirable objectives and aims should be ignored or disregarded, but only that they should not determine the content.

The criterion of significance is thus reformulated as follows:

The content should be significant (a) in so far as it provides for the understanding of principles and the essential, related factual knowledge, which are meaningful at the appropriate activity level, and (b) in so far as it conveys the methods of the investigative procedures of the discipline or disciplines on which the school subject is based.

3.5.3 The criterion of balance

This criterion is mentioned by various authors, although some, e.g. Nicholls and Nicholls simply echo Taba's original statement in only very slightly modified form. They state:

Breadth and depth should be appropriately balanced, and yet breadth of coverage and depth of understanding appear to be conflicting objectives. If

there is too much emphasis on coverage there is likely to be insufficient attention and time given to the development of intellectual skills and processes which organise knowledge and make it useful to the learner...⁶⁹

In his development of this criterion, Searles⁷⁰ points out three important implications, viz. (a) curriculum content may give greater emphasis to discipline content and exclude "informal" content; (b) curriculum content may give greater emphasis to informal content to the exclusion of discipline content; and (c) the depth of treatment given to the content of the curriculum may vary.

The question of breadth of coverage also emerges from the concern many authors show about the mass of work that many curricula try to cover:

How even a selection of this accumulated knowledge, which is adequate, is to be studied in a time which it is possible to make available, is the centre around which revolve many of the present problems in the teaching of science. Quite a number of them arise from the attempt to do too much in too short a time.⁷¹

Similar objections are raised against the depth of treatment in many modern science curricula. Elsworth and Pay,⁷² for example, remark that "the results (of their investigation) convince us that the chemistry section of the current syllabus for physical science is too ambitious in its goals through attempting to incorporate advanced modern concepts, some of which belonged to third-year university chemistry courses only 30 years ago!"

These extracts underline the essential need for the criterion of balance of breadth and depth. It is therefore not surprising that this criterion was generally accepted by all curriculum specialists and educationists interviewed. The criterion of balance can thus be accepted as formulated.

3.5.4 The criterion of relevance

This criterion, too, receives general support in the literature, although it may be found in a variety of different forms. Michaelis et al.⁷³ call it "relevance to significant human activities, problems, and issues, and frequency and criticality of use". What is evident, however, is that in some instances the emphasis is placed more heavily on one particular aspect, e.g. social relevance, to the exclusion of others such as cultural relevance. The implications of this lack of balance has already been pointed out in Chapter 6, Section 3.5.7.

In interviews this criterion was unanimously supported, and it was pointed out that the addition of the phrase "in particular to the life of the pupil" was essential. "One should be careful not to apply this criterion on the basis of the adult culture and society only".⁷⁴

This criterion and its formulation is accepted.

3.5.5 The criterion of interest

Pupil interest as a determinant for the selection of content is stated or implied by very nearly every work on the curriculum and on teaching methods. This is an area where the very close relationship between content and method is perhaps the most marked.

The emphasis on this criterion also varies considerably. On the one hand, there are those, such as Richmond, who advocate a curriculum based on pupil interest, whilst at the other end of the scale others, like Barrow, simply state that the curriculum should have due regard for their interests. The first point of view, in the words of Richmond⁷⁵ is:

The most promising signs for the future development (of secondary education) are to be found... in the moves now being made to devise courses of an interdisciplinary nature in which the subject-matter is used to illustrate broad themes, topics, areas of inquiry and issues of immediate interest and relevance to adolescents...

What knowledge is of any worth?... Whatever the answer, we can be sure that it varies from individual to individual. Why so? Because, to repeat, the form-creating capacity is ultimately to be found only in the learner himself.

According to this pedocentric approach to the curriculum, the only worthwhile knowledge, and, therefore, worthwhile curriculum content, is that which is based on the interests of the pupils themselves. The type of curriculum that logically emerges from such an approach, is termed the "open curriculum" by Buttle:⁷⁶

An alternative approach to curriculum formulation which may be free from the above weaknesses (of the "expert-oriented" curriculum) is to focus on the interests of the learner. These reflect his values and thus are not reliant upon external validation.

Barrow presents detailed arguments to show that a distinction should be made between "what interests children" and "what is in the interest of children" and that the term "pupil interest" should thus be clearly defined. He then turns to the child-centred approach:

What is to be said about this approach to the curriculum? The first point to clear up is the distinction between proposing that children's interests should provide the starting point for a curriculum, and the proposal that they should govern the whole content of the curriculum. The former suggestion effectively reduces interests to a motivational role. On this view the school has predetermined objectives and some predetermined content that it wishes to impart to children, but it approaches the content by means of the children's actual present interests... Since, therefore, it is in essence a methodological claim, and says nothing about how one might determine the objectives and content that the child is ultimately supposed to attain by way of his interests, we need not pursue it here.

The theory that really needs examining is the view that a worthwhile curriculum would be one that consisted almost exclusively of taking up and exploring children's actual interests. Would such a curriculum be worthwhile? It might be argued that this is the approach... we should adopt, on the grounds that nobody has produced an argument to show that any activities are intrinsically worthwhile. This being so, we have no right to proceed as if some activities are just worthwhile, and should rather respect individual differences. But this argument clearly will not do. In the first place, even if we accept that we have not yet found, and are unlikely to find, an argument that establishes the intrinsic value of certain activities, it does not follow automatically that this theory is acceptable. At present we have no more reason to accept it as true that a curriculum based on children's interests is worthwhile, than we have to accept that a curriculum based on Hirst's forms of knowledge is worthwhile. Secondly, even if we were to accept a thesis to the effect that the value of an activity lies in the individual's interest in it, it is surely clear that we would need to draw a distinction between children and adults.⁷⁷

Barrow continues the argument at some length and concludes that the interests of children may be of some importance to the educator and that it would be both wrong and unwise to ignore them as a matter of policy, but that it cannot be shown that a worthwhile curriculum can be constructed by reference to children's interests alone.⁷⁸

An intermediate point of view is explained, but not necessarily subscribed to, by Buttle:⁷⁹

This particular orientation does not necessarily imply that all the learner's interests should be followed up; apart from obvious practical difficulties there

is the possibility that his interests are unethical, trivial or ephemeral. But they provide a basis for negotiation between teacher and pupil. Nor does it follow that the learner's interests are already educated; they merely provide starting points and it is up to the teacher to educate by providing significance, structure and shape, and by increasing the understanding that the learner has of them.

This view differs from Barrow's interpretation of what pupil interest as a "starting point" involves, and is more than simply "a methodological claim". According to Buttle the actual selection of the content is effectively in the hands of the pupils and it is the task of the teacher, firstly to screen the interests the pupils wish to pursue and, secondly, to develop these interest-topics by "increasing the understanding" of the pupils in these areas.

All three^{of} these points of view, or variations of them, also emerged from the interviews. Those who support the approach represented by Richmond, found the preliminary statement of the criterion too weak and not positive enough. The author is thus forced to present and motivate a personal point of view in order to resolve the question of the interpretation of this criterion.

This point of view is briefly the following: A set of criteria, or even principles, operate collectively and not singly. As soon as any single criterion is elevated to the status of a primary, determining principle, an unbalanced system is created. The history of education teaches this very clearly, especially the history of the unbalanced educational systems evolved in authoritarian countries. This type of imbalance can also operate in a part of the system, such as the content of the curriculum. Any procedure for selecting content will give rise to a curriculum of imbalance, if the selection procedure is based on any single criterion, be it pupil interest, validity, significance, or any other. The author thus rejects the validity of a curriculum based solely, or even largely, on the interests of pupils.

On the other hand, it should be appreciated that (other factors being equal) effective and efficient learning occurs best when the learning materials are based on the familiar world of the learner himself. Heinrich Roth⁸⁰ states that the child requires some form of motivation which relates to his natural interests or which stimulates or generates natural interests. For this one should turn to those interests which are available from the actual "life-world" of the child at his particular age and level of maturity. Although this relation to and generation of natural interests are mainly methodological problems, which will be referred to again in Chapter 9, content, too, can be selected in such a way as to take note of the natural interest of the child, or for the purpose of generating such interest: the content should both take into account and provide for pupil interest. Stated in these terms, this criterion is accepted.

3.5.6 The criterion of learnability

This criterion is specifically mentioned or explained by quite a number of authors, such as Taba, Wheeler, Nicholls and Nicholls, to mention but a few. It is also implied, or formulated in different terms, e.g. "Adaptability in terms of children's capabilities and backgrounds",⁸¹ "content appropriate for the readiness of the pupils",⁸² and the like, by the majority of curriculum writers in their discussions on the content of the curriculum.

None of the specialists interviewed by the author questioned this criterion or its formulation in any way and it would seem as if it is generally accepted as a matter of course as being an obvious, common-sense condition.

Nicholls and Nicholls⁸³ formulate this criterion as follows:

It perhaps seems obvious to say that what is included in the curriculum should be learnable by the pupils, but the criterion of learnability, however obvious it may be, is not always satisfied. The main problem is that of adjustment to the abilities of the pupils. Content must

be available in forms which are appropriate to the pupils, and these will, of course, be different for different pupils. It is also important that what is to be learned makes a connection with something which the pupils have already learned, and again this will vary from one pupil to another. This suggests the need for variety in the ways in which content is made available and in the manner in which pupils are expected to learn it.

Their interpretation of this criterion goes beyond the selection of content but also includes "ways in which content is made available" (method) and "the manner in which pupils are expected to learn it".

Taba mentions four aspects of this criterion:

1. "One factor in learnability is the adjustment of the curriculum content and of the focus of learning experiences to the abilities of the learners."⁸⁴
2. "The problem of making the curriculum learnable involves also the task of translating the social heritage into experiences which help each student to make it his own."⁸⁵
3. Learnability is "this criterion of appropriateness to life experience."⁸⁶
4. "... this method of applying the criterion... indicates the use of the life experience of students first as a bridge to new learning and then again as a way of assuring transfer of learning to new phenomena."⁸⁷

Here again, one finds an overlap with method in the translation of content into learning experiences, and also repeated reference to the "life experience" of the pupil. This expansion of the criterion of learnability is obviously an aspect of the criteria of relevance and of pupil interest, and especially of the methodological implications of the application of these criteria.

One could also ask whether the aspect of "adjustment to the abilities of the learners" is not included in the criterion of balance of breadth of coverage and depth of presentation and understanding. If "depth of presentation and understanding" is taken to mean that the content selected should be developed and taught at a level and to a depth that the children can understand and master, there is no need for an additional criterion of learnability.

In spite of the general acceptance of this criterion as "an obvious one" by educational authors and by the specialists interviewed, the author rejects this criterion as duplication and restatement of aspects of other criteria, especially those of relevance, balance and pupil interest.

3.5.7 The criterion of fundamentality

Taba includes this criterion under the heading "validity and significance of content" and states that "perhaps the more important question about validity of content is how fundamental the knowledge is".⁸⁸ Michaelis and his co-authors suggest as a criterion that the subject matter should be useful in "explaining a wide variety of phenomena and developing a sense of structure of the field of study",⁸⁹ whereas Margenau includes a criterion of "universal applicability".⁹⁰ The major modern curriculum projects in physics and chemistry also consider fundamentality as "so important that no course is complete without it".⁹¹ It would seem as if Taba's interpretation of "how fundamental the knowledge is" refers mainly to its "breadth of application and provision for the acquisition of new knowledge" (see Section 3.3.2), and is thus broadly similar to Michaelis' and Margenau's wide or "universal" applicability.

Interviews with educationists and curriculum workers produced a variety of diverging responses, ranging from complete rejection "as incompatible with modern trends in curriculum development and applicable only to traditional, discipline-based curricula"⁹² to insistence that it be "separated from Taba's criterion of validity and significance and (be) stated separately as a criterion on its own".⁹³

Here again one is confronted with a criterion, the inclusion of which cannot be resolved simply from the opinions and arguments of authors and curriculum workers. For inclusion in the proposed model for curriculum design, each criterion should be applicable to every level of teaching, ranging from the activity levels of the nursery and primary schools to those operating at the tertiary level. If one accepts Bruner's thesis that "any subject can be taught to any child in some honest form",⁹⁴ it may be possible to argue for the inclusion of this criterion. The author finds it impossible to subscribe to this view of Bruner, especially at the level of the very young pre-primary and primary school pupil. That a child may learn some aspects of a subject is conceded, but that he may learn "a subject", even in an extremely simplified form, is a completely unrealistic view. The selection of "fundamental" knowledge because of its greater explanatory powers, cannot be justified at all levels of the curriculum. In this sense and context, fundamentality is simply an aspect of the criterion of validity which starts operating at the appropriate activity level. This level should not be lower than that at which the pupils can begin to understand the essential nature and structure of the discipline or disciplines from which the school subject is derived.

The second aspect of this criterion is explained in terms of "the potential to generate new knowledge": the more fundamental the knowledge is, the better will it provide for the acquisition of new knowledge. It is not quite clear from Taba's discussions whether the acquisition of new knowledge means a further development of the subject by the gradual addition of more complex aspects and increase in depth of treatment, or whether it refers to knowledge obtained by the learner himself by application of the "fundamental" knowledge to new situations. From Searles' interpretation of Taba's original statement, it is taken to mean the former. If this is the case, it is obvious that what is meant is "pre-requisite" rather than "fundamental" knowledge; that is, fundamental in an educational sense rather than in the context of the structure of the subject or discipline. This aspect is accommodated in the next criterion of consistency.

The criterion of fundamentality of the content is thus rejected as a separate criterion since its two major components are provided for by the criteria of validity and consistency.

3.5.8 The criterion of consistency

The criterion of consistency of structure is stated or implied in the publications relating to most of the major curriculum projects analysed. This is usually stated in terms such as "designed in order to develop conceptual models" (Nuffield), "should reflect the logical structure and unity of the subject" (PSSC) or the "ideas that characterise physics as a subject" (Project Physics). Perhaps the best example of a fully consistent structure of knowledge is to be found in the Chemical Bond Approach Project, as is illustrated by Fig. 7.1.

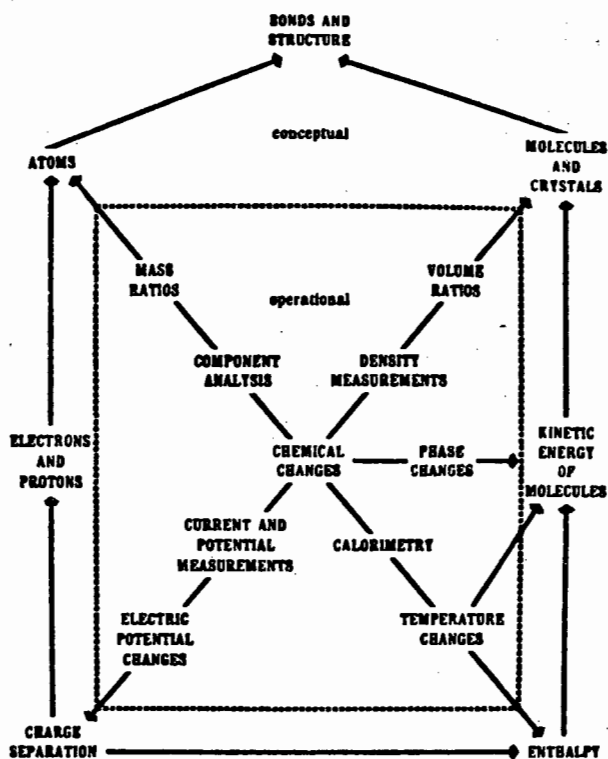


Fig. 7.1 Chemical Bond Approach content paradigm⁹⁵

This criterion is also mentioned by Margenau (internal consistency), Wheeler (pattern), Hurd (correlation), Michaelis (usefulness in developing a sense of structure of the field of study), and others.

Although this sample represents four different formulations, each one refers to the consistency of structure of the content selected.

The tentative formulation used during the author's interviews with educationists and curriculum workers involves more than just the consistency of structure of a field of knowledge, and contains three major aspects, viz. (a) the content should be non-contradictory and internally consistent; (b) the concepts should form a consistent developmental hierarchy; (c) the different parts of the content should correlate as far as possible.

These three components may be illustrated by simple examples of inconsistencies found in curricula: (a) a course based rigorously on the correct use of SI units and symbols, suddenly reverts to the definition and use of the calorie in the study of heat; (b) the unit approach to the curriculum which includes a variety of short topics, such as force, textiles, water treatment, etc. without any clear developmental structure; (c) an integrated science course which develops the concepts of energy and energy transformations in physics, but completely ignores the correlation with the energy aspects of biology.

This criterion received fairly general support from the majority of educationists personally consulted, coupled with a lack of enthusiasm about consistency of structure from many from the Leeds Group. They agreed with the formulation presented to them, but not with the interpretation that a discipline type of structure of knowledge is implied by the phrase "concepts should form a developmental hierarchy". This should be taken to refer to the development of the child rather than to the development of the subject.

The author's interpretation is that both these aspects are involved in any "known-to-unknown" and "simple-to-complex" structure: the structure of the subject should be selected and designed to match the development of ability and understanding in the pupil.

Curriculum content which fails to make provision for the prerequisites, be these skills, factual knowledge or supporting simpler concepts, in order to understand major concepts and principles, is internally inconsistent. Similarly, if any prerequisite concepts are introduced at a stage not suited to the level of understanding of the pupils, these concepts cannot later serve effectively to develop major concepts and principles. The application of this criterion must, therefore, be interpreted in relation to the "activity level" for which the curriculum is designed. At primary and junior levels the stage of development of the child will be of much greater importance than the structure of the subject; at the senior secondary level, the structure of knowledge will operate as well. At the tertiary level, where selected, mature students are involved, the discipline structure becomes the major aspect of this criterion.

The Weizmann Group supported the author's view and suggested that the criterion be reformulated as follows:

The content should be internally consistent, i.e. it should be non-contradictory, form a mutually supportive developmental hierarchy of facts, concepts and principles, and provide for correlation between the various parts.

3.5.9 The criterion of disciplinary structure

A curriculum which is "a representative sample of the structure of the discipline" does not apply to primary and junior work and can perhaps only be fully implemented at the tertiary level. Those aspects of discipline structure applicable to the different activity levels of the curriculum model are already included in the criteria of validity and consistency, and, conversely, the application of these criteria at the tertiary level, will provide for a discipline structure at this high level.

It is, therefore, considered unnecessary to repeat and discuss the arguments of authors on education or the arguments offered by the

experts interviewed. The inclusion of this criterion is not considered to be necessary or compatible with the suggested curriculum model.

3.5.10 The criterion of examination requirements

Although this criterion may be of extreme practical importance in centralised educational systems having external examinations or examining bodies, complete curriculum evaluation, which includes pupil assessment, forms part of the proposed model. It is thus argued that the evaluation should be devised as part of the development of the model and not that the model should be designed or adapted to allow for the requirements of an existing examination system. Examination requirements cannot determine the content of the curriculum but should be designed to test the effectiveness of the content in achieving the aims and curriculum objectives.

Closely related to this criterion is Muller's⁹⁶ statement about general requirements for content which includes, inter alia, agreement among textbooks, agreement among curricula and emphasis on certain content by examiners. Textbooks, which are aids and which form part of curriculum materials, should not determine curriculum content but should be written for, and as part of, a curriculum. Similarly, agreement among curricula can be the result of the application of common curricular principles, but not a fundamental criterion for the selection of curriculum content.

3.5.11 The criterion of teachability

This criterion was not included in the original preliminary list, but was suggested by the Weizmann Group. Their arguments for the inclusion of this criterion are briefly as follows:

Content (in the sciences) may be selected which, although it can comply with all the criteria listed, should, nevertheless, not be included because it cannot be taught effectively. The reasons for the "unteachability" of such content may be simple, such as practical

problems of apparatus and facilities, lack of sufficient funds, or the possibility of danger and harm to the pupils. Other difficulties may arise from the academic and professional education of teachers, from the length of time required to teach the particular content, problems in designing suitable teaching-learning aids, experiments and apparatus.

The arguments offered by the Group are valid ones, but again, the curriculum model does provide for these mainly methodological and practical implications of the selected content. Apart from the criteria for teaching-learning experiences that may be evolved from methodological principles, the interaction between the elements of content, organisation and method provides for feedback to modify content selection in the light of the other two elements.

3.6

The final formulation of criteria for content

The final six criteria, phrased somewhat differently, are as follows:

1. Validity. (a) Is the content valid in the sense that it is appropriate to, and lends itself to the attainment of, the curriculum aims?
 (b) Is the content valid in the sense that it represents authentic, true and up-to-date knowledge?
2. Significance. (a) Is the content significant in so far as it provides for the understanding of principles and concepts, and for the related, essential factual knowledge which are meaningful at the appropriate activity level of the curriculum?
 (b) Is the content significant in so far as it conveys the methods of the investigative procedures characteristic of the subject discipline(s)?

3. Balance. Does the content represent an appropriate balance of breadth of coverage (scope) and depth of presentation and understanding (difficulty and complexity)?
4. Relevance. Is the content relevant to life in general and to the life of the pupil in particular, i.e. to the social and cultural environment of the pupil?
5. Interest. Does the content take into account and provide for the interests of pupils?
6. Consistency. Is the content internally consistent in that the various parts are non-contradictory, form a mutually supportive hierarchy of facts, concepts and principles, and are correlated as far as possible?

Finally, it should be pointed out that the content should be selected on the basis of, and judged against, all these criteria and that a single criterion should not be elevated to the position of the main determining criterion. At the same time, it should also be realised that not all of the criteria will be applicable to the same extent to every topic or unit and that the curriculum designer should endeavour to achieve the optimum balance in applying the criteria. Many of these criteria, such as significance, relevance and interest, are not completely independent of method and may be re-evaluated during the stage of designing the appropriate teaching-learning activities. Similarly, the criteria of balance and consistency cannot operate independently of the organization of the content, a topic which will be discussed in more detail in the next chapter.

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CHAPTER 8CRITERIA FOR THE ORGANIZATION OF CONTENT

The parts are never greater than the whole. The parts do, however, buttress the whole; they are the materials that must be shaped and fitted together meaningfully...

- Frank A. Butler¹

What is simple logically, however, may not be simple psychologically.

- Harry N. Rivlin²

1. INTRODUCTION

It is an educational truism that piecemeal learning is not efficient and that principles, facts and skills are best learned when they are learned in a pattern and not as isolated bits of subject matter.³ The curriculum content must thus be arranged in some kind of order: the various selections of content "must be shaped and fitted together meaningfully". Again, the main controversy centres around the interpretation of what is meant by meaningful organization. Some schools of thought base their concept of meaningful arrangement on the logical structure of knowledge as represented by the discipline from which the school subject is derived; others concentrate on a structure that is meaningful to the child, deriving their organizing principles from "interest units" rather than from the structure of the subject or discipline.

Muller⁴ identifies four major organizational principles. According to his analysis of educational and subject literature, these principles are as follows:

- (a) A random organization based on the preference of the curriculum designer, the order of appearance of topics in standard textbooks, and/or the historical sequence of publication of original research papers.

- (b) A logical organization, or subject-centred approach, based on the discipline structure.
- (c) A psychological organization, or child-centred approach, based on the needs, interests, aptitudes, maturity and level of intellectual development of the pupils.
- (d) A logical-psychological organization which simultaneously takes into account both the logical requirements of the subject and the psychological needs of the child.

Although the major issue of organization of content revolves around the logical-versus-psychological argument, Muller's selection of only four major principles is too simplistic and limiting to be of practical use to the curriculum designer. What is required are, as Stenhouse puts it, "principles for making decisions about sequence"⁵ or, in other words, a set of suitable criteria.

2. CRITERIA FOR THE ORGANIZATION OF CONTENT

2.1 Criteria derived from analysis of curricula

2.1.1 The Nuffield Science Teaching Project: O-level Physics and Chemistry

The authors of the Nuffield schemes emphasise that their programmes are not syllabuses in the generally accepted sense of this term. This statement is repeated in the headings to the "topic outline" for each year of the physics course.⁶ Yet, elsewhere it is stated:

This is a suggested programme, and we hope that teachers will make choices and modifications as they think best. We do not claim our programme is ideal though we have tried to make a connected scheme - and on the latter count, we hope teachers will consider trying out our scheme in our suggested form, before making modifications which might break up the connections unexpectedly.⁷

This statement, and the remark "If you chop pieces out of it, it bleeds"⁸ clearly show that, although the term syllabus may be consciously avoided, a fairly highly organized structure is intended. The main statements about organization are the following:

1. The physics scheme is not structured on the grounds of a logical development of the subject. "Children are not logical in their thinking. They will not thank us for strict logic in building our teaching order..."⁹
2. The main organizing principle is the development from an informal acquaintance with concepts and instruments in the early years, towards reinforcement and a more reasoned discussion of the same concepts in a more rigid manner in the later years.¹⁰
3. The "connected scheme" is structured by first determining the ultimate aims for the pupils and then by finding out what earlier topics seem to be needed to support those aims and to provide the groundwork for understanding the teaching in the later years.¹¹
4. The chemistry scheme utilizes the "unit approach" to organization, or as it is called, a "topic-by-topic" course.¹² Unity is obtained by providing links with "other scientific studies so that science is seen in relation to the life of the community as a whole..."¹³

2.1.2 The PSSC Physics Course

1. The course is organized around the development of four major concepts, viz. space, time, matter and motion.¹⁴ These concepts serve as unifying themes in order to lead students "to realize that physics is a single subject of study".¹⁵
2. These concepts are presented in a number of selected study units, viz. waves and radiation, Newtonian mechanics, conservation of gravitational mass, inertial mass and energy, and the wave-particle dualism.¹⁶

3. The topics are, in turn, "selected and ordered to progress from the simple and familiar to the more subtle ideas of modern atomic physics".¹⁷
4. Within each topic the treatment is fairly rigid and the role of mathematics in physics as well as the appreciation and understanding of logic in the interpretation of experimental results, is constantly emphasised. Although only certain topics are developed, the approach is basically discipline-based.

2.1.3 The Project Physics Course

1. This course, too, is organized in the form of six study units, viz. concepts of motion, motion in the heavens, the triumph of mechanics, light and electromagnetism, models of the atom, and the nucleus. The organizing principle, according to the authors, is to concentrate "on ideas that characterize physics as a science at its best, rather than concentrating on isolated bits of information."¹⁸
2. Each unit, and the course as a whole, is presented in historical perspective and links with present-day culture are provided throughout.

2.1.4 The Chemical Bond Approach

1. The concept, the chemical bond, is selected as the unifying theme around which the course is structured.¹⁹
2. The organization is a strictly logical one, leading to a rigidly interconnected structure of topics and concepts. This organization is presented diagrammatically in Chapter 7, Section 3.5.8, Fig. 7.1.

2.1.5 The CHEM Study Course

1. The course content is based on the development of major chemical principles, rather than on the study of units or topics.

2. More difficult principles and concepts, e.g. chemical bonding, are introduced during the later stages of the course rather than in the "accepted" logical sequence of development.
3. The illustrative material, or "factual subject matter", is selected in order to illustrate the principles with the minimum of "exceptions". Some systematic chemistry is introduced towards the end of the course to provide the opportunity for application of the principles developed earlier on.
4. Wherever possible, the material for each principle is organized and structured in such a way that the "relationship between experiment and theory" is systematically developed.²⁰
5. According to the authors the course is organized in such a manner that "chemistry is logically and gradually unfolded."²¹

2.1.6 The Scottish Certificate of Education Examination Board: Physics (Ordinary and Higher Grades) and Chemistry (Ordinary and Higher Grades)

1. Both these courses are organized in a logical manner based on the structures of the disciplines.
2. The Physics Course is based on a topic or unit approach, containing units which show a remarkable similarity to those of the PSSC course.²²
3. In the introduction to the Chemistry Syllabus it is stated that the arrangement of the syllabus is designed in order to be able to present the subject in such a way that the pupils may discover the majority of facts for themselves.²³

2.1.7 The Nordrhein-Westfalen Physics and Chemistry Courses

These courses have a formal, disciplinary structure, starting from introductory work on mechanics, waves, electricity and energy in physics which are developed in greater depth in later years with the addition of more difficult topics such as studies of alternating current, electronics, theory of relativity and quantum physics in

the final stages of the Gymnasiale Oberstufe.²⁴ The chemistry curriculum is introduced, perhaps rather uniquely, through a six months section on organic and biochemistry (Einführung in the Chemie des Kohlenstoffs), a topic which is again taken up in the final year of the three year course. The rest of the course is organized around the traditional topics, such as electronic structure of the atom, chemical bonding, particle model of matter, reaction kinetics, equilibrium, electrochemistry and reaction mechanisms.²⁵

Summarising, it may be said that the main organizing principles are

1. a logical organization based on modern ideas about the structures of the two disciplines;
2. a developmental hierarchy from simple to complex and the provision for prerequisite knowledge during the early stages;
3. a certain amount of spiral organization by means of the repetition of certain topics at an increasing level of complexity.

2.2 Criteria derived from educational literature

It is remarkable that only a few authors on curriculum design and development give any attention to criteria or practical principles for the organization of the selected content. The majority of American writers seems to repeat or rephrase Taba's original chapter on organization of curriculum content²⁶, whereas the major work of Continental European origin concern themselves with broad generalisations about organization.²⁷ What little has been published locally, tends to follow the approach adopted in Europe.²⁸

2.2.1 Van der Stoep and Van der Stoep²⁹ present six "principles" for the organization of curriculum content:

1. The progressive principle

The authors state that this principle, which they interpret as the successive teaching of different subjects, does not exist in modern educational practice anymore.

Aarts, however, employs the same term, but interprets it as a chronological progression as applied, for instance, in the teaching of history.³⁰ He contrasts it to the "regressive principle" according to which the planning starts with the present, going back to, or referring to, the past as may be required.

A third interpretation of the term "progressive" in the context of arrangement of subject matter can also be found. This view involves the so-called "five popular maxims"³¹ of progression, viz. (a) from the known to the unknown; (b) from the concrete to the abstract; (c) from the particular to the general; (d) from the easy to the more difficult; (e) from the simple to the complex. To these may be added the "maxim" derived from Gestalt psychology: (f) from the whole to the parts.

2. The concentric principle

This principle is also mentioned by Aarts. He defines it as that organization by which the same subject matter is repeated every subsequent year, but developed in greater scope and depth.³²

3. The chronological principle

Although the authors state that this principle is particularly suitable for organizing the content of subjects such as history, art history, Biblical studies and aspects of language teaching³³, it is also found in science curricula as the "historical approach" or "historical method".³⁴

4. The symbiotic principle

This principle may be defined in the authors' own words: "As a principle for the organization of content it indicates that the curriculum is not compiled in terms of subject divisions but on the basis of organizing the content as it is found in the concrete life situation."³⁵ They illustrate this principle by reference to the project approach, the German "Gesamtunterricht

Decroly's principle of "centres of interest" and the Dutch-Flemish approaches of "Real or Life Education".

5. The integration principle

This principle refers to the provision of links with different areas of the same subject, with other subjects and with real-life situations and applications. The principle is applicable at different levels, ranging from the simple correlation of various topics to the complete eradication of subject barriers. The integrated science movement provides an example of attempts at eradicating the traditional division of the sciences into separate disciplines such as physics, chemistry, geology, botany, zoology, etc.

6. The principle of core content

Although this principle is related to that of integration, it entails many possibilities which cannot be derived from integration. This principle is based upon the arrangement of subject matter around a core or focus and the provision of supplementary programmes for certain pupils or groups of pupils. The authors list eight advantages of this approach.³⁶

2.2.2 Aarts³⁷ presents the following approach to the organization of content:

(a) Methods of arrangement

1. The subject-systematic method based on the systematic arrangement, or logical development, of the subject.
2. The psychological method. "One takes the psychological development of the pupil as starting point and in the arrangement of the subject matter one will then follow the order of the developmental sequence (ontwikkelingsgang) of the pupil".³⁸
3. The pragmatic method. This method may be illustrated by organizing a study of biology according to the seasonal availability of plants and animals, or by arranging the curriculum for geography from the locality of the school as a starting point.

(b) Division into time units

The curriculum is designed for a number of school years. The content must, therefore, first be organized in year units and then be subdivided into smaller units, such as term units or month units, week units and lesson units.

(c) Types of curriculum organization

Depending on the approach used, the following main types of organization may result:

1. A concentric curriculum.
2. A successive curriculum. In this type of curriculum the subject matter is arranged in a successive sequence in such a manner that the total content is gradually and progressively covered over the total course period.
3. The progressive (chronological) curriculum.
4. The regressive curriculum. Aarts's interpretation of these terms was explained in section 2.2.1.
5. The combination curriculum. Aarts states that the above-mentioned organizational curriculum types are only rarely found in pure form in practice and that combination curricula are usually applied in schools.

2.2.3 Michaelis, Grossman and Scott list a number of what they call, "key factors in organizing the curriculum".³⁹ According to these authors "there are four key factors to consider in organizing the total curriculum, an area of the curriculum, and units of instruction":⁴⁰

1. Scope or breadth of the curriculum

The scope of the curriculum is related to the objectives and the contribution each can make to major goals. The scope is defined in terms of conceptual, process, skill and affective objectives, main ideas of conceptual schemes, or basic activities, and is "operationally set" by these objectives.

2. Sequence

"Sequence is planned to provide an order of instruction that optimizes children's learning and is consistent with the logic of the subject matter."⁴¹ According to them, sequencing is combining the psychological and logical ordering of content and learning activities and involves (a) moving from the simple to the complex; (b) planning in terms of prerequisite learning; (c) moving from the whole to parts; (d) considering pupils' needs for personally and socially useful knowledge.

3. Cumulative learning

Cumulative learning, or continuity of learning, is closely related to sequencing but "deserves special comment".⁴² In the context of curriculum organization it refers to the provision of opportunities to reinforce and apply previous learning and to extend and enrich learning as the child proceeds from one level to another. The main technique for this purpose is spiralling or cycling of topics.

4. Integration of learning

The authors refer to integration within units of instruction, within areas of the curriculum and across areas of the curriculum.

2.2.4 Wheeler⁴³ discusses the following three principles of organization:

1. Scope and sequence.
2. Organizing centres.
3. Integration.

Elsewhere he refers to "pattern of learning experiences"⁴⁴ and formulates six principles for interrelating learning experiences to form a pattern, viz.

1. balance;
2. continuity;

3. practical continuity;
4. cumulation;
5. repetition of experiences;
6. multiple learning.

2.2.5 Hilda Taba's criteria for organization are well-known.⁴⁵

They are the following:

1. Determine the sequence.
2. Provide for cumulative learning.
3. Provide for integration.
4. Combine the logical and psychological requirements.
5. Determine the focus.

(This criterion is broadly similar to Wheeler's "organizing centres" and to Van der Stoep and Van der Stoep's "principle of core content". Taba even uses similar terms in her discussion. She states that one of the main principles of organization is "to decide which element of the curriculum can serve as such a focus or centre of organization"⁴⁶ and she also refers to "using core ideas as focusing centres".⁴⁷)

6. Provide a variety of modes of learning.

2.3 The list of preliminary criteria

2.3.1 Introductory

A number of problems arose during the process of formulating preliminary criteria for discussion and critical evaluation. These problems mainly concerned the uncritical and undefined use of the terms "logical organization" and "psychological organization".

Analysis of curricula, such as the Nuffield Chemistry Scheme, often reveals a logical structure which does not conform to the generally accepted interpretation of the logical arrangement of

the discipline. Moreover, more than one different logical structure may be designed, depending to a large extent on the particular content selected.

In the case of the term "psychological" one may find that the same author lists "psychological organization" and, for example, "provide for cumulative learning" as two distinctly separate criteria, although the latter is also based on psychological principles. Clearly, there are a number of criteria that may be referred to as "psychological". One could, like Muller⁴⁸, include all those criteria based on psychological principles under a single heading, but this would severely limit the practical value of such a criterion for the curriculum designer.

It has thus been decided not to equate the term "logical structure" to "structure of the discipline" and, in order to remove any ambiguity in interpretation, to use the term "systematic structure" instead. Also, in line with the method of application of the criteria for the other elements, all the criteria should be applied in the organization of the content. It is, therefore, not a case of "either-or", but of organizing the curriculum content in such a way that each criterion is applied to maximum advantage. Thus a "psychological organization" which excludes a systematic content structure, and vice versa, is unacceptable. The broad, or collective, term "psychological organization" may very easily be interpreted as the only or major principle of organization of content and will, therefore, not be used as a criterion as such.

2.3.1 The preliminary criteria for organization

Criterion 1: The content should be organized to yield a systematic subject structure. A systematic structure may be described as an organization that provides for, and takes into account, the logical development and structure of the subject or sections of the subject, as well as the subdivision of the content into suitable teaching and study units.

Criterion 2: The content should be organized to match and be compatible with the stages or phases of intellectual development of the student. The development of concepts, conceptual schemes and principals should be structured and sequenced to develop from simple fundamental knowledge to more complex concepts. Provision should be made for all essential prerequisite knowledge (skills, facts and concepts) which is required for the development of the concepts and principles included in the selected content, and this development should be spread over the optimum period of time.

Criterion 3: The content should be organized to provide for cumulative learning. Cumulative learning implies more than the additional mastery of greater amounts of facts. This criterion also refers to the provision of opportunities for pupils to reinforce and apply previously acquired knowledge (skills, facts, concepts and principles) in order to improve their mastery of this knowledge, to extend and enrich their learning and to gain a deeper understanding. This may be attained by means of the application of various organizational techniques such as a spiral structure, the overlap of units, provision for application and revision, etc.

Criterion 4: The content should be organized in such a way that optimum provision is made for integration of subject matter. Integration may be accomplished at various levels of application, ranging from the provision of links between topics, units, parts of the same subject and different subjects, to the complete integration of the components of the school subject, e.g. physical science may be organized as a single subject without any division into, or distinction between, physics and chemistry. Some of the better-known techniques of integration are the unit approach, the project approach, the modular approach and the thematic approach.

Criterion 5: The organization of content should be in agreement with accepted methodological progressions. These may be listed as proceeding from (a) the known to the unknown; (b) the concrete to the abstract; (c) the particular to the general; (d) the easy to the more difficult; (e) the simple to the complex; (f) the proximate in time and location to the more remote; (g) the whole to the parts.

Criterion 6: The organization should be practical. A practical organization takes into account such factors as the seasonal availability of organisms and specimens for biology, climatic variations, e.g. the problems of teaching of electrostatics during a humid period, availability of apparatus and facilities, the level of experimental and other skills required of the pupils, etc.

Criterion 7: The organization of content should provide for a variety of modes of learning. Modes of learning depend on modes of instruction. The traditional content organization which simply lists the topics to be studied in a chosen sequence, usually results in verbal learning based on direct instruction and the use of textbooks. This may be accompanied by some kind of laboratory work and demonstrations. By organizing the content in such a way that laboratory work and demonstrations, for example, are integrated with the content, a greater variety of modes of learning may be achieved.

2.4 The refinement of the criteria

2.4.1 The criterion of systematic subject structure

All the curricula studied and scrutinised reveal some kind of systematic structure or organization, although the organization may not necessarily be based upon the generally accepted "logical structure of the discipline".⁴⁹

This criterion is also mentioned, or implied, by most curriculum writers. Aarts⁵⁰ calls it "the subject-systematic method" and also discusses the further organization of the curriculum into suitable time units. Other authors use a different terminology to express the same idea, e.g. Michaelis, Grossman and Scott's "sequence"⁵¹, Wheeler's "scope and sequence"⁵² and Taba's "logical requirements".⁵³

Only among the supporters of the so-called "open curriculum" (see Chapter 2, section 2.3) does one find a dissenting view.

The open curriculum will thus be seen to be flexible, hypothetical and tentative - and individual"⁵⁴ but, as Joseph Buttle⁵⁵ remarks, "perhaps we are now beyond curriculum".

Daniel Tanner⁵⁶ presents an excellent summary of the arguments for and against a disciplinary approach and concludes:

Ideally, knowledge should be so selected and organized in the curriculum that there is no discernible dichotomy between the "logical" and "psychological" ordering of subject matter. Although many of the new curriculum projects are intended to eliminate this distinction by interpreting the disciplines as systems by which man discovers and develops new knowledge, the subject matter often represents the world of the mature scholar and not that of the child or adolescent.⁵⁷

He advocates a curriculum for "general education" and states that "disciplinarity can be made to contribute to interdisciplinarity, particularly for the purposes of general education".⁵⁸

Tricker⁵⁹, too, expresses concern about the "educational value" of the curriculum, and adds:

Although... the pursuit of science consists in the construction of pictures by which experience may be correlated, if the picture is to be of any value the elements in it must be subject to logical rules. Science thus must possess a logical structure which,

together with the basis for it, must be understood for the study of the subject to attain the educational value of which it is capable.⁶⁰

Personal discussions with curriculum experts produced a similar variety of points of view, but no new or enlightening arguments. In general, however, the present trend towards integrated science, and the emphasis on, and interest in, mixed ability education, tend to favour the pupil-centred rather than the subject-centred approach to organization of the curriculum.

The point of view propounded by the author is that the criterion of a systematic subject structure is an essential organizational requirement. This criterion does not imply that the organization should be based on the accepted logical structure of the discipline, but that the organization should represent a systematic subject structure. A number of different "logical" structures may be possible, depending, inter alia, on the age and level of development of the pupils, the particular selection of content, the time allocated to the subject in the time table, and other factors. If education, and therefore also teaching, is to be a purposeful activity directed towards the attainment of valid educational aims and objectives, the organization should reflect this purpose and direction.

In addition, it should be pointed out that a logical organization forms part of the structure and activities of science itself. Although scientific discoveries and breakthroughs do not always take place in a logical sequence, and although the logical structure of a subject may only become apparent after the acquisition of large amounts of knowledge and understanding, it is the organization of these discoveries, this knowledge and understanding which eventually provides the logical structure of the discipline. If science teaching is to reflect this aspect of science, a systematic subject organization is essential.

This criterion, with the emphasis on subject structure and not on discipline structure, is thus accepted for this study.

2.4.2 The criterion of developmental sequence

According to Tanner and Tanner⁶¹ traditional curricula have largely been based on the notion that a child's mental structure is the same as that of the adult, and that the child merely lacks the adult's range and depth of knowledge:

Under this assumption, curriculum construction was regarded as properly the adult's logical formulation of organized subject matter to be imposed unilaterally upon the child (as a miniature adult). A modern statement of this view is made by Bruner who, as chief theoretician for the discipline-centred curriculum reforms of the space-age era, proposed that the child's intellectual activity is essentially the same as that of the adult scholar and that any differences are of a matter of degree, not of kind.⁶²

The concept of the child as "an ignorant adult" has been disproved by a variety of studies, notably those of Piaget and the German thought-psychologists such as Külpe, Ach, Bühler, Lindworsky, Frohn, Sassenfeld, Schaefer and Selz. Further light is cast upon the development of thinking and concept formation by the work of psychologists such as Gagné and Ausubel. The problem confronting the curriculum designer is not the lack of theories about learning and the development of mental and intellectual abilities, but rather the multitude of approaches and theories. An effort towards some kind of clarification was made by Watson⁶³ in his What Psychology Can We Trust? in which he listed a number of propositions on the assumption that most psychologists, regardless of the "school" to which they belong, would agree with them. By using such a list it should be possible to apply the "psychological" criterion to organize the selected content to follow developmental sequences, to provide for prerequisite knowledge and skills, to apply what little knowledge we have of concept formation and to provide for cumulative learning, rather than to subscribe uncritically to one particular "school" of psychology.

Support for this point of view is found in the literature among authors such as Taba⁶⁴, Oliver⁶⁵, Tanner and Tanner⁶⁶, Hofacker⁶⁷, and others. Hofacker, referring in particular to the teaching of chemistry, even suggests that the accepted conceptual structure of chemistry needs to be re-examined and redesigned in order to make it compatible with the student's intellectual development.

The "psychological" criterion for curriculum organization received unanimous support from the curriculum workers consulted. This support ranged from agreement with the criterion as stated in the preliminary formulation, to statements of the completely child-centred approach to curriculum organization. Within this range of opinions were some who supported particular psychological ideas, such as Professor K. Lovell's bias towards Piagetian theory⁶⁸ and the emphasis on the theories of Gagné among the contributors to the Schools Council Integrated Science Project (SCISP).⁶⁹

The formulation of this criterion was often criticised as being too limited in scope, thus excluding important psychological considerations. Such criticism, however, is "a reflection of the domination of the curriculum by psychological thought"⁷⁰ and inevitably arises from a completely child-centred approach to organization.

More valid criticism was levelled against the use of the terms "stages or phases".⁷¹ These terms may imply that such clearly defined stages may be identified or actually exist, whereas developmental changes occur gradually and may vary considerably among different individuals.

The criterion is thus retained, but is reformulated as follows: The content should be organized to match and be compatible with the physical, mental, intellectual and emotional development of the pupil.

2.4.3 The criterion of cumulative learning

"Providing for cumulative learning" is one of Taba's major organizational criteria. She defines it as "to provide for a

progressively more demanding performance: more complex materials to deal with, more exacting analysis, a greater depth and breadth of ideas to understand, to relate, and to apply, and a greater sophistication and subtlety of attitudes and sensitivities. This may involve either short-term or long-term sequences, depending on the nature of the task."⁷² In addition to the provision for increasing complexity of material, she also includes a "cumulative spiral" to provide for "continual reinforcement by continuing in use that which has been acquired, either through practice or through use in new context..."⁷³

Similar formulations and applications of this criterion, or aspects thereof, have already been discussed in sections 2.1.7, 2.2, 2.2.2(c) and 2.2.3 of this chapter.

From the author's discussions with curriculum workers it became clear that some aspects of this criterion, e.g. provision for more complex and demanding content, apparently overlap with the criterion of developmental sequence, whereas other aspects, such as continual reinforcement and application, involve other dimensions. A distinction should be made, however, between simply organizing the content in a sequence which progresses from the simple to the complex (cumulative learning) and organizing the content in a sequence that parallels pupil's intellectual development (developmental sequence). The criterion of cumulative learning would, for example, determine the organization of a learning sequence for the study of atomic models, whereas the criterion of developmental sequence would be involved to determine the appropriate age at which first to introduce this topic, and at what stage more advanced models, such as the quantum-mechanical interpretation, could be studied.

It was also pointed out that one of the major organizational problems, viz. that of making decisions about the frequency and duration of the teaching and learning of a particular content topic, is provided for in the application of this criterion.

The criterion is thus retained as formulated.

2.4.4 The criterion of integration

Integration, as a criterion or "principle" of curriculum organization, is mentioned or discussed by the majority of curriculum writers, e.g. Taba⁷⁴, Tanner and Tanner⁷⁵, Oliver⁷⁶, Michaelis, Grossman and Scott⁷⁷, Nicholls and Nicholls⁷⁸, Gottlieb⁷⁹, and others.⁸⁰ In many instances integrated science curricula, e.g. Scottish Integrated Science and the Schools Council Integrated Science Programme (SCISP), Nuffield Combined Science, the Australian Science Education Project (ASEP), and others, have been developed mainly for school level, but in some cases also for college⁸¹ and undergraduate⁸² courses. The school courses are examples of a fairly general trend in Western education, which is based on the premise that the aims of a general science education for mixed ability classes are best attained through integrated courses. Similar programmes have been "exported" to many developing countries through agencies such as Unesco, often with very little knowledge of, or apparent concern for, the local needs, culture and socio-economic conditions.

The advantages⁸³ and disadvantages⁸⁴ of fully integrated courses have been discussed by various authors, and the same, or similar points of view were offered by the curriculum specialists interviewed. Although "it is recognized that learning is more effective when facts and principles from one field can be related to another, especially when applying this knowledge",⁸⁵ a single criterion should not be inflated at the cost of other, equally valid, criteria. When efforts at integration become artificial and develop into clever artifices of curriculum design, rather than the provision and reinforcement of natural links, it defeats its own purpose. The interpretation of this criterion, in Taba's words, "throws the emphasis from integrating subjects to locating the integrative threads".⁸⁶

This criterion is retained as originally stated. It, therefore, does not exclude integration of subjects provided that the content areas selected for inclusion in the subjects are closely and naturally related.

2.4.5 The criterion of methodological progression

Although this criterion may overlap with both the criterion of developmental sequence and the basic methodological principles (Chapter 9), it deserves special consideration in the context of organization of content. It could be viewed as the methodological criterion of organization.

This criterion is included under the heading "sequence" by Michaelis, Grossman and Scott⁸⁷ and by Smith, Stanley and Shores⁸⁸, is mentioned by Taba⁸⁹, and referred to by various authors on curriculum.

It would be possible, as is done by Taba, Michaelis, Grossman and Scott, and others, to combine the criteria of systematic structure, developmental sequence and methodological progression into the single criterion "sequence" or "determine the sequence" but such a composite criterion would be too general and cover too many different aspects to be of practical guidance to the curriculum designer. A separate statement about this aspect of sequencing is thus deemed essential.

2.4.6 The criterion of practicality

The need for this criterion, especially in the field of science curricula with their unique component of laboratory work and practical investigations, is self-evident. The application of this criterion should not, however, simply be left to the teacher, but should be applied by the curriculum worker in the design and development stages of the curriculum.

2.4.7 The criterion of variety of modes of learning

This criterion, which is developed in some detail by Taba⁹⁰, refers to the organization of "learning experiences" rather than to the organization of content. This is obvious from Taba's exposition and the examples used to illustrate her arguments. This interpretation is confirmed by Wheeler's criterion of "repetition of experiences".⁹¹

Since provision may be made for a variety of modes of learning by the application of sound methodological principles, this criterion is not retained.

2.5 The final formulation of the criteria for organization

Six criteria for organization of content are thus retained:

1. Systematic subject structure;
2. developmental sequence;
3. cumulative learning;
4. integration;
5. methodological progression;
6. practicality.

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CHAPTER 9METHODOLOGICAL PRINCIPLES AND CRITERIA FOR TEACHING-LEARNING ACTIVITIES

... The problem is not to practice any particular method, conventional or progressive, but to apply the... principles at the highest possible level.

- James L. Mursell¹

1. INTRODUCTION

1.1 Can methodological principles be identified?

In spite of labels such as "traditional methods" and "progressive methods" it would seem as if all effective teaching techniques and methods may be reduced to a number of universally valid principles. One can identify the same principles of good teaching in the methods of the great teachers through the ages - Aesop, Socrates, Christ, Comenius, Pestalozzi, Herbart, Froebel, Montessori and Decroly - although the emphasis on the different principles may vary from one individual to the other. Similarly, many of the so-called "progressive methods" may in reality be old or "traditional" methods that have been re-emphasised and adapted to the modern classroom situation and to the new technologies available to the teacher. Modern methods may often be regarded as the rediscovery of old methods and the design of new possibilities for application.

Comparison of the different "principles" formulated by various educationists, reveals the same kind of similarity and agreement. The number and formulations may differ, but essentially the same general principles emerge:

Various authors, such as Bevelander, Mursell and Butler made classifications of what they regard as the most important principles. In studying these classifications it becomes clear that, apart from the variety of classification possible, certain basic principles appear time and again and claim recognition in any classification. One

also comes to the conclusion that there is such a coherence among these principles that a discussion of the one invariably involves one or more of the others.²

1.2 Principles and rules

Good teaching, as Butler³ points out, is not simply the application of rules and techniques, "but rather... the grasping of those basic principles supporting good teaching anywhere and everywhere". However important the practice and mastery of rules and techniques may be, the theoretical principles on which they are based are more fundamental and important. Thus a large number of different applications of the same principle may be possible in different teaching situations. The principles provide the guidelines on which the teacher must base his methods and his design of sound teaching techniques, but they do not provide foolproof rules or blueprints for successful classroom practice.

1.3 The formulation of principles

Methodological principles are derived mainly from the psychological and pedagogical analysis of the process of learning.⁴ The existence of different schools of psychology and theories of learning inevitably gives rise to a large number of different formulations and classifications of methodological principles. The remarkable similarities inherent in these formulations may be ascribed to the practical element: the time-tested criterion of classroom experience. From the variety of formulations and classifications available from the literature, a representative selection will be provided. From this selection a set of principles will be formulated which are relevant to curriculum design and implementation.

2. METHODOLOGICAL PRINCIPLES DERIVED FROM LITERATURE

2.1 Butler's eight principles of teaching

Butler⁵ arrives at his principles from an analysis of "the complete teaching act" and states that "the eight principles lean heavily upon educational psychology, especially on those divisions pertaining to types of learning, motivation, and individual differences".⁶

He formulates his principles as follows:

- "1. The objectives should be most worth while.
2. Pupils learn through self-activity, but this activity should be psychologically sound.
3. Self-activity to be psychologically sound should be in fullest agreement with the type or types of learning involved in attaining the objectives.
4. Learning should be unitary, not fragmentary.
5. The energy of the pupils should be released so that they apply themselves fully.
6. Teaching should provide for individual differences.
7. Teaching should be diagnostic and remedial.
8. The physical and social environment for learning should be ideal."

It should be pointed out that principles 2, 3 and 5 refer to pupil activity and may be seen as aspects of a single, more general principle.

2.2 The six principles of successful teaching of J.L. Mursell

James. L. Mursell⁷ formulates six principles which, he states, "comprise the author's bridge between psychology and the classroom".⁸

1. The principle of context: the meaningfulness and therefore the effectiveness of learning depends largely on its context.

2. The principle of focus: meaningful and effective learning must be organized around a focus.
3. The principle of socialization: the meaningfulness and effectiveness of learning depends to an important extent upon the social setting in which it is done.
4. The principle of individualization: meaningful learning must proceed in terms of the learner's own purpose, aptitudes, abilities, and experimental procedures.
5. The principle of sequence: the sequence of meaningful learning must itself be meaningful, if authentic results are to be obtained.
6. The principle of evaluation: the effectiveness and success of any job of learning is heightened by a valid and discriminating appraisal of all its aspects.

Mursell introduces the concept of "levels of application" of principles: "Thus, for each principle, one gets a hierarchy or scale by which actual teaching practices can be rated and arranged in an ascending order of excellence according to whatever psychology can tell us about how the principle in question ought to operate."⁹

2.3 Duminy's five most important didactic principles

Duminy¹⁰ selects five principles as the most important. He states: "They are unquestionably rooted in the healthy didactic situation, formed by the teacher, pupil and subject matter, and point directly towards the day-to-day problems encountered in the primary and secondary school classroom."¹¹

1. The principle of totality: According to this principle man is regarded as a unity, a totality, or a whole. Although various dimensions of this "multi-dimensional unity" of man can be distinguished, they can never be divorced or separated. In education this principle reflects the ideas of synthesis or integration, co-operation

between school, home and community and the extension of the acquisition of knowledge to areas other than the intellectual, such as the will and emotions.

"This principle can be regarded as the most comprehensive of the principles that will be dealt with... The 'new education' or the 'new didactics' finds its main support in what can collectively be called the modern psychology of totality."¹²

2. The principle of individualization: According to Duminy this principle is based on the idea that every child must be assisted to develop according to his own capabilities.
3. The principle of motivation: This principle is concerned with the educationally sound and justifiable methods of arousing and maintaining the will to learn.
4. The principle of perception: The psychology of cognition teaches that knowledge is based on, or has its starting point in, concrete experience and the perceptible.
5. The principle of environmental teaching. The teaching of the child should emanate from his environment ("Heimat" (German) or "heem" (Dutch)).

2.4

Aarts' principles and classification

Aarts¹³ classifies his selection of didactic principles as follows:

A. Fundamental principles

1. The spontaneous developmental urge.
2. Self-discovery.
3. Self-activity.
4. Interest.
5. Observantness ("opmerkzaamheid").

B. Structural principles

1. Perception.
2. Apperception and continuity.
3. The environmental principle.
4. The truth and value principle.
5. The principle of expression.

C. Consolidation principles

1. Repetition.
2. Application.

D. Personal principles

1. Individualization.
2. Socialization.

2.5 Principles generally accepted by the phenomenologists

The following eight principles are those usually included in the writings of the phenomenologist school of Education.¹⁴

1. The principle of totality. Stone¹⁵ calls this the "core principle" in the education of the child.
2. The activity principle. This includes self-activity, which is given as a separate principle by some authors.
3. The principle of perception. This principle refers to the child's becoming aware of the concrete world through his senses as well as to the child's internalization ("innerlike belewing") of the external observations.
4. The developmental principle. This principle is based on the findings of developmental psychology and takes into account the physical, intellectual and emotional development of the child.
5. The principle of individualization. The child is a person with his own unique abilities and nature.

6. The principle of socialization. This principle is derived from the premise that man's task is carried out among and together with others.
7. The principle of authority ("gesagsbeginssel"). Neither the pupil nor the teacher is completely free in the educational or teaching situation: the learning situation requires a certain amount of control in order to attain the desirable objectives.
8. The principle of freedom. This principle should be interpreted in conjunction with the previous one: man has the freedom of choice, but this freedom is subject to the authority of certain accepted rules and norms.

Stone¹⁶ points out that these principles should not be separated. Although one of them may receive relatively more emphasis in a particular teaching situation, the principle of totality should always be regarded as the basic, unifying principle. Even apparently contradictory principles such as individualization-socialization and authority-freedom are to be interpreted as being complementary rather than contradictory.

3. METHODOLOGICAL PRINCIPLES FOR CURRICULUM DESIGN

3.1 Introductory

From a study of the principles summarised above the author has selected and formulated the following nine as especially relevant to curriculum design and in particular to the design of educationally sound teaching-learning activities:

1. The principle of goal directedness.
2. The principle of systematic planning.
3. The principle of totality.
4. The principle of pupil interest.
5. The principle of perception.

6. The principle of activity.
7. The principle of individualization.
8. The principle of humanization.
9. The principle of mastery.

These principles provide for and accommodate all those discussed in the literature with the exception of evaluation.¹⁷ Evaluation is, however, one of the elements of the proposed curriculum model, and this aspect is treated separately and in greater detail in Chapter 10.

A detailed discussion of the educational, psychological and social foundations of these principles, their full implications in the practical teaching-learning situation and the various techniques for their implementation would be out of place in a work of this nature. The discussion which follows will, therefore, be limited to a brief formulation of each principle, followed by reference to some of the more important implications and applications.

3.2 The nine methodological principles

3.2.1 The principle of goal directedness

Effective teaching requires that the teacher and pupils see, know and understand the aims and objectives of every teaching-learning situation clearly in order to apply themselves to their attainment.

This principle has a threefold implication, viz.

- (a) clarity of goal;
- (b) directed, conscious purpose;
- (c) clear formulation of the tasks involved.

It has implications for a number of curriculum areas, e.g.

- (a) effective planning is impossible without clear aims and objectives;

- (b) clear objectives are required for the purposeful choice of aids and techniques;
- (c) motivation requires that the pupil be made goal-conscious;
- (d) evaluation implies assessment of whether objectives have been attained.

3.2.2 The principle of systematic planning

Effective teaching requires sound and careful planning of teaching-learning activities for the attainment of the curriculum aims and objectives.

This principle includes aspects of the "principles" such as focus¹⁸, sequence¹⁹ and continuity²⁰ mentioned by other authors. Systematic planning refers to the application of the criteria for selecting content, determining the organization and designing methods and techniques for evaluation and assessment. It is also applied in the selection and design of aids, methods and techniques and has implications for discipline: "The teacher's careful planning can anticipate and prevent disorder."²¹

Some planning units and relationships are the following:

- (a) co-operative planning;
- (b) course planning;
- (c) planning for different time units, e.g. for a year, a term, a week, a day;
- (d) lesson planning.

3.2.3 The principle of totality

Effective teaching requires that the teacher aids his pupils in seeing each part of the learning content in its proper perspective in relation to the whole, and enriches the pupil's learning so that it becomes more meaningful.

Because of its many implications and applications this principle is difficult to formulate in a single statement. It involves, inter alia, the following:

1. Meaningfulness of content, e.g.
 - (a) placing parts, topics, sections in their correct context and relationship;
 - (b) pointing out and emphasising relationships;
 - (c) forming associations;
 - (d) providing links;
 - (e) integrating with other topics and subjects.
2. The learning process, e.g.
 - (a) association and chaining;
 - (b) learning by wholes (Gestalt) and the application of the globalization principle;
 - (c) concept formation;
 - (d) transfer of learning.
3. The education of the whole child, e.g.
 - (a) mind-body unity, i.e. involving hand, head and heart;
 - (b) integration of personality;
 - (c) the child in his total world-environment.

3.2.4 The principle of pupil interest

Effective teaching requires that the teacher obtain and maintain the interest of the pupils to the highest degree possible.

The formulation does not imply that the teaching must only be based on or be closely related to the interests of the pupils, but that the teaching itself should arouse the interest of the pupils. Attention, which is essential for effective teaching, can be obtained only by creating interest in the teaching-learning activity. In addition, pupil interest forms a major component of intrinsic motivation.

Some of the ways of stimulating interest, i.e. of the application of this principle, are

- (a) making use of the natural curiosity of the child;
- (b) knowing and applying the laws of attention (intensity, contrast, variety);
- (c) satisfying the basic and secondary needs of pupils;
- (d) providing and using links with the pupils' current interests;
- (e) enriching the meaning of the material (see the principle of totality);
- (f) providing a variety of teaching-learning activities for each topic;
- (g) adding a touch of humour.

3.2.5 The principle of perception

Effective teaching is lifelike and involves the application of all those visual, auditory, tactile and other sensory experiences necessary to approximate or recreate the real-life situation.

This principle has major implications for the learning process - positive as well as negative - and requires careful application. Some examples are

- (a) introduction of new topics and concepts by means of the concrete;
- (b) illustration;
- (c) application of skills and knowledge;
- (d) internalization and integration of observations in the pupil's cognitive and conceptual structure;
- (e) transition to abstract reasoning and learning;
- (f) interference caused by concrete and visual elements.

Many aids and techniques are available for the application of this principle, e.g. traditional and modern audio-visual aids, acting and dramatizing, environmental and community resources, etc.

3.2.6 The principle of activity

Effective teaching requires that the pupil be actively involved in the teaching-learning process, both physically and mentally.

Some of the implications of this principle are the following:

1. Physical activity:

- (a) the release of the physical and nervous energy of pupils;
- (b) the need for physical participation and involvement;
- (c) the practising of skills;
- (d) the practical application of knowledge.

2. Mental activity:

The teacher can stimulate mental activity through -

- (a) application of the psychological principle of active learning;
- (b) use of imagination and thought experiments;
- (c) setting assignments;
- (d) questioning.

In practice the application of this principle relates to methods as well as to teaching style, e.g.

- (a) the question-and-answer method;
- (b) discussion methods;
- (c) the heuristic method;
- (d) the project method;
- (e) the problem-solving style of teaching.

3.2.7 The principle of individualization

Effective teaching provides for individual differences.

This principle may be applied at various levels, e.g.

- (a) establishing rapport with and involving each pupil;
- (b) respecting each pupil as a unique individual;
- (c) encouraging individuality and independence;
- (d) adapting the teaching to individual differences in ability, progress, needs, background, personality and character;
- (e) grouping pupils (mentally or physically);
- (f) fully individualizing instruction (e.g. by teaching in a one-to-one relationship or by using programmed instruction).

Some of the methods and techniques available to the teacher for the application of this principle are

- (a) homogeneous grouping of classes;
- (b) fixed or fluid grouping within the class;
- (c) streaming;
- (d) setting;
- (e) the core-plus approach;
- (f) classroom and administrative differentiation;
- (g) individual assignments and projects;
- (h) programmed instruction and machine teaching;
- (i) computer managed instruction (CMI) and computer assisted instruction (CAI).

3.2.8 The principle of humanization

Effective teaching requires constant awareness of and emphasis on human values, relationships and interest.

The principles of "socialization", "freedom" and "authority" mentioned by other authors are all included in this principle. It has, however, wider implications and includes aspects such as

- (a) social relationships and interactions²²;
- (b) emphasis of human values;
- (c) emphasis of human relationships;
- (d) the human interest approach (cf. Project Physics);
- (e) education towards the attainment of the ultimate aim of education (cf. Chapter 6).

The application of this principle operates through the content, teaching method and teaching style.

3.2.9 The principle of mastery

Effective teaching requires that pupils should master the selected skills and knowledge.

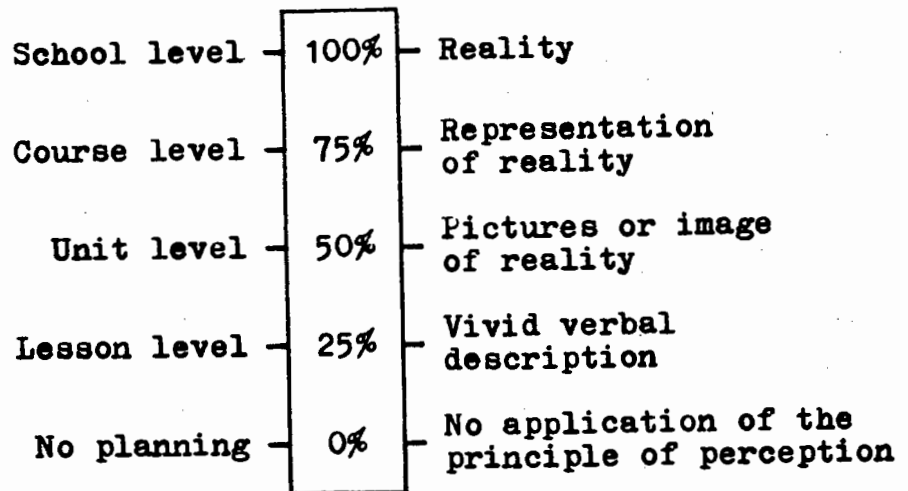
This principle refers to the application of the results of the psychology of learning and of study, guidance on study methods and revision techniques, repetition, drill and application, and it can also be provided for in the organization of curriculum content, e.g. by spiralling.

4. THE APPLICATION OF METHODOLOGICAL PRINCIPLES

4.1 Levels of application

Mursell's introduction of the idea of a "scale of applications"²³ of methodological principles focuses the attention on an important aspect, viz. that each principle may be applied in the classroom at different levels of application and with varying emphasis. It is very difficult to visualise a teaching situation in which all the principles can simultaneously be applied at their maximum level. The opposite, however, is well-known: in many actual teaching situations some principles may be regularly ignored, or applied at their lowest possible level.

The following diagram (Fig. 9.1) illustrates possible levels of application of two different methodological principles.



Levels of application of the principle of systematic planning

Levels of application of the principle of perception

Fig. 9.1 Different levels of application of methodological principles

The different levels are chosen arbitrarily and do not imply the existence of a quantitative scale. The level of application of each principle in any particular teaching situation depends on a variety of factors ranging from the content to be taught and learned to the physical environment in which the teaching takes place. Whatever these conditions may be, all principles should be applied at the optimum level allowed by and possible under the prevailing circumstances.

4.2

The interrelation among the principles

All nine principles are closely interrelated. "Indeed they merge into one another continually, for they are simply ways of looking at the same process - the process of meaningful learning."²⁴ In curriculum design they form the guidelines for the construction and planning of suitable and effective teaching-learning activities. One cannot select or emphasise only one or a few principles and ignore the rest without ending up with an unbalanced curriculum.

The history of education - including the very recent history of curriculum innovation - abounds with examples of curriculum failure as a result of ignoring this interrelationship. Any curriculum which places all its eggs in one methodological basket, is doomed to failure. One cannot, for example, use programmed instruction as the only method of instruction of a curriculum based on individualization without losing all the educational benefits of totality, humanization, pupil interest, activity and perception. Although such an approach may involve the application of individualization and mastery of content at very high levels, the losses in terms of the aims of education are too great.

Many curricula, although they may involve all or most of the principles in the design of their teaching-learning activities, often emphasise a particular principle out of all proportion, e.g. the principle of totality in project approaches; pupil activity, usually in the guise of discovery methods, in many modern science curricula; and pupil interest in the open curriculum. These curricula, too, may be termed "unbalanced" in terms of the level of application and interrelationship of methodological principles. It is suggested that the viability of a curriculum is greatly dependent on the degree of balance obtained in its design and structure.

5. CRITERIA FOR TEACHING-LEARNING ACTIVITIES

5.1 Some criteria derived from the literature

Criteria for the selection and design of "learning experiences" are given or implied by various authors, including Taba²⁵, Michaelis, Grossman and Scott²⁶, Oliver²⁷ and Wheeler²⁸. Wheeler's list of criteria, being the most comprehensive, is presented here.

1. Validity in so far as it actually does to some degree bring about the behavioural change specified in an objective.
2. Comprehensiveness (scope), i.e. all objectives should have corresponding learning experiences.

3. Variety.
4. Suitability as to levels of development of the group and of individuals.
5. Pattern. Aims are interrelated; consequently experiences must likewise be interrelated to form a pattern.
6. Relevance to life.
7. Pupil participation in planning.

5.2 The need for criteria for teaching-learning activities

Comparison of the criteria suggested for the selection and design of teaching-learning activities with the methodological principles reveals that all the criteria are included in these principles. Thus, validity is an aspect of goal directedness; comprehensiveness forms part of the principle of totality; variety is but one component of individualization; suitability is provided for by systematic planning; pattern may be included under both totality and systematic planning; relevance to life forms the basis of the principle of perception; pupil participation is part of the principle of activity.

Since methodological principles are, according to Butler²⁹, "guides which keep instructional activities pointed in the right direction", they are in fact criteria for the design and classroom implementation of effective teaching-learning activities. Consequently there is no need for the formulation of separate criteria: the curriculum-in-action should only be founded on the principles of a sound methodology of education.

6. LABORATORY WORK AS A TEACHING-LEARNING ACTIVITY

6.1 Introductory

Laboratory work or "practical work" is a teaching-learning activity characteristic of science teaching. The special role of practical work in the teaching of science has been discussed and debated.

with varying emphasis since H.E. Armstrong's The Teaching of Scientific Method was published at the turn of the century. In 1903, the year of publication of Armstrong's book, Professor A. Smithells³⁰ supported this heuristic-experimental approach in the following words:

What Professor Armstrong has done has been to formulate a scheme of teaching in accordance with the principles which are almost as old as civilisation. The aim of this scheme is to free science teaching from the dogmatic, the didactic methods by which it has been dominated, and to substitute a system which should yield the benefits of the experimental method. Two things, and only two, are essential to his plan: first, that pupils should perform experiments with their own hands, and secondly, that these experiments should not be confirmation of something learnt on authority, but the means of discovering something previously unknown, or of elucidating something previously uncertain.

Armstrong's approach was also severely criticised, both in England and on the European Continent:

It is nothing better than make-believe and fraught with grave intellectual danger.³¹

He (the pupil) cannot expect to rediscover in his school hours all that he may fairly be expected to know; to insist that he should try to do this is to waste his time and opportunities.³²

The initial controversy gradually simmered down. Then, in 1959, came the Woods Hole Conference and Jerome Bruner, and during the 1960's and onwards, inquiry-discovery through pupil experiments and investigations again became a slogan in curriculum reform.³³ Again arguments for and against this approach started to fill the pages of educational journals and texts, but, as the following two contrasting quotations show, these arguments did not essentially differ from those offered at the beginning of the century:

"Finding out" is always exciting. By adopting as one of its principles a fuller use of the investigational method in chemistry teaching, the Nuffield Science Teaching Project hopes to let pupils savour something of the pleasure and satisfaction accompanying any exploration of the unknown... The heuristic spirit has motivated much good and effective teaching. In terms of present needs, Armstrong's work has fostered the belief that chemistry should be presented in a lively and imaginative way, and not as a dull routine of memorized factual information.³⁴

Typical of the opposite view, is the warning:

The idea of putting the pupil always in the position of scientific investigator in which he is led to "discover" facts, can be strained too far. Surely the hand of Professor Henry Armstrong does not rest on us so heavily that we must go on equating school science with the laboratory.³⁵

While many claims are made for learning by discovery, these claims have yet to be substantiated by empirical research.³⁶ The same can be said of the arguments raised in opposition to this teaching method: most of the criticisms, too, are based on opinion rather than on fact.

6.2 An approach to practical work as a teaching-learning activity

It would seem obvious that laboratory work or practical work as an educational activity, should be approached as a particular type of teaching-learning activity and that it should be subject to the same principles or criteria. From the literature on curriculum design and science education it would seem, however, that this is not the case: practical work in school science is almost always treated as something unique or special.

It is suggested that laboratory work, as an essential component of science, should not be confused with inquiry-discovery through

pupil experiments. The former is part of the content of the curriculum; the latter is a method of teaching. It is thus essential that the various aims formulated for practical work³⁷ and the claims made for practical work as teaching-learning activity³⁸, should be critically weighed against the criteria formulated for curriculum objectives, content, organization and method. If this were to be done, it would be obvious that the elevation of the heuristic method based on pupil experiments and investigations to the position of the approach to science teaching cannot be justified. This is also true of those approaches which totally reject the heuristic-experimental approach. Practical work in this context is but one of the methods available to the curriculum designer and the teacher, and should be employed wherever it proves to be the most effective. The decision whether and where to employ such activities should, however, be based not on personal preference but on sound curriculum criteria.

6.3 Practical work and the methodological principles

Pupil experiments obviously can comply readily with the principles of (a) pupil interest, (b) activity and (c) individualization. Experiments co-operatively designed and carried out in groups also lend themselves to the application of many aspects of the principle of humanization, especially with regard to its socialization aspect. The meaningful application of the principles of goal directedness, systematic planning, totality, perception and mastery, however, are not so self-evident in many of the so-called practical approaches.

6.3.1 Practical work and goal directedness

The observation by the author of classes in which free inquiry methods were employed, often revealed a lack of goal directedness.³⁹ Although the teacher may have had clear aims in mind, discussions with the pupils revealed that they were primarily concerned with the actual activity itself without being consciously aware of the major aim to which the activities were supposed to lead.

Teachers usually become aware of this fairly soon after the introduction of an inquiry-discovery curriculum and try to remedy this deficiency by resorting to the so-called "guided discovery" methods and the use of structured work sheets. This lack of understanding of the broader purpose of a series of practical laboratory activities is closely related to the low level of application of the principle of totality.

6.3.2 Practical work and totality

There exists a real danger that a series of activities may be carried out by the pupils without proper provision for the understanding of their context in and relationship to the concept, principle or subject being studied. This fragmentation of the content by the application of inquiry-discovery methods was observed in a number of schools using a work sheet approach to the teaching of the Scottish Integrated Science Course.⁴⁰ In contrast, a combination of inquiry-discovery methods and classroom teaching of the more "traditional type" which was observed in a private Grammar School in the London area, was remarkably successful in making the pupils realise the context and purpose of the activities they were carrying out.⁴¹

6.3.3 Practical work and systematic planning

It is generally recognised that effective, purposeful practical work in the school laboratory requires careful planning and organization. From an educational point of view the important aspect of this planning should be concerned with the design of suitable teaching-learning laboratory activities and their integration with the overall teaching programme, but in practice the textbook or worksheet experiments are usually used uncritically and most of the planning effort is devoted to the pure physical aspects such as the preparation of solutions, the setting up of apparatus and equipment and the organization of the class. This is certainly the case in most South African schools where teachers

have to do without laboratory technicians and only one province (Natal) has laboratory assistants in its schools.

Another kind of lack of planning may be observed in those systems where great emphasis is placed on the free inquiry-discovery approach. Here, too, much energy is devoted to the physical aspects, but very little purpose is evident in the activities carried out by the pupils.

6.3.4 Practical work and perception

At first glance it would seem that pupil experiments lend themselves to an extremely high level of application of the principle of perception. In these activities the pupils are involved in "the real thing" and are actually carrying out real scientific investigations. They are "scientists for the day".⁴²

It is generally accepted that the principles of perception and activity are intimately interrelated. Observing and perceiving are integral parts of the learning activity. In order to form clear concepts, which are prerequisites for clear thinking and reasoning, the child must learn through observation. Thus effective aids for the application of the principle of perception are necessary.

It should be realised, however, that concrete observations and experiences only obtain real meaning when they become internalized, that is, when they are integrated with and form part of the existing cognitive and conceptual structures in the mind of the child. Although observation and perception are conditions for abstraction, especially in the early school years, limiting teaching to these methods means that the child is actually retarded in the development of his thinking and reasoning. A curriculum approach based exclusively on pupil experiments as the means of imparting knowledge and understanding is thus bound to fail. To obtain order and pattern from the multitude of inquiry-discovery activities, abstraction through verbal teaching and reasoning is essential.

A second important aspect in this regard, is the so-called "perception barrier"⁴³. When a pupil observes an experiment, a variety of aspects, data and characteristics may be perceived more or less simultaneously. Many of these observations may have no direct bearing on the concept being investigated and should be disregarded, or at least be mentally filed away separately for later follow-up. Similarly, if some of the essential observations, required for understanding of the concept, go by unnoticed, an incomplete or wrong idea may result. In order to contribute to meaningful and correct concept formation, perception and observation should be directed and effective; if not, it causes a barrier to concept formation.

Very often, as the content of learning material becomes more complex, the results of previous learning activities have to be recalled for the formation of new concepts. Not all prerequisite knowledge can be repeated every time it is needed. The recall of prerequisite knowledge which does not contribute to the concept, or may distract from the concept, is called interference. According to the results of investigations on the psychology of learning, interference is very often due to the intrusion of visual and other perceptual elements. Especially when the new concept is based mainly or partially on abstract reasoning, as is often the case in the upper levels of secondary physics and chemistry, this tendency towards concrete visualization (or concretization in the terminology of learning psychology) may seriously impair concept formation.

6.3.5 Practical work and mastery

Mursell⁴⁴ states that successful teaching is teaching that brings about effective learning.

The decisive question is not what methods or procedures are employed, or whether they are old-fashioned or modern, time-tested or experimental, conventional or progressive. All such considerations may be important but none of them is ultimate, for they have to do with means, not

ends. The ultimate criterion for success in teaching is - results!

To obtain these results it is essential that the pupil should master the learning content. This implies more than the ability to recall facts but requires mastery of the skills, facts, knowledge and understanding in order to comprehend, apply, analyse, synthesise and evaluate⁴⁵ successfully.

In designing practical work as a teaching-learning activity the different aspects of mastery should be kept in mind. A curriculum involving a full programme of pupil experiments may, for example, have as one of its outcomes great skill in the handling of apparatus and equipment but very little understanding of the theoretical aspects related to the experiments.

Tricker⁴⁶ states that

One of the most important features of the investigation, as opposed to the laboratory exercise, is the design of the experiment, which is an essential part of it. It is entirely absent from the exercise.

On practice in laboratory techniques and skills, he remarks:

The need to acquire a technique will depend entirely upon the possibility that the pupil will later put it to use.⁴⁷

The programme of practical work should thus be designed to provide for mastery in more than one context, ranging from the practical exercise in the essential skills and techniques to the design of investigations in order to solve problems and to provide the opportunity to apply knowledge previously acquired, and even as a means for evaluating the mastery of certain abilities and fields of knowledge.

6.4 Summary and conclusion

Practical work, which ranges from the teacher demonstration to the individual pupil experiment, has two main components. Firstly, experiment is part of all science disciplines and as such should form part of the content of the curriculum. In the second place, practical work can be an effective aspect of teaching method and can serve as the basis for the design of meaningful teaching-learning activities. In both cases practical work should be viewed in the proper perspective, and its inclusion, design and planning must be evaluated against the appropriate criteria and methodological principles.

Wherever practical work forms the basis of a teaching-learning activity it should be remembered that "the degree of learning and of retention is influenced by the quality and the extent of the students' mental activity; it is affected only little by the amount of meaningless manipulation that is done."⁴⁸

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CHAPTER 10CRITERIA FOR CURRICULUM EVALUATION

Indeed, it seems to be a characteristic of Man that he evaluates, judges or appraises almost everything which comes his way, but the criteria which he uses for his evaluations, judgements and appraisals are often highly egocentric. It is easier to form opinions than to make judgements. Curriculum developers have not been exceptional in this respect.

- John F. Kerr¹

1. INTRODUCTION

1.1 Interpretation of the term "evaluation"

To evaluate literally means "to determine the value of", i.e. to find out the worth of something. In this sense curriculum evaluation would simply mean to find out what the curriculum is worth as a vehicle for the attainment of the ultimate aim of education. In order to do this it would be necessary to apply all the available evaluation techniques to determine to what extent and how successfully each of the contributory curriculum aims and objectives has been attained. However, curriculum objectives themselves are not absolute and the history of education clearly illustrates how they have changed - and are still changing - both in nature and in emphasis. Even the way in which they are formulated is subject to new ideas and approaches, as is made evident by the behavioural objectives movement of the last two decades.

This changeableness in curriculum objectives, and consequently also in curriculum evaluation, is further compounded by the various interpretations of the term "evaluation" found in educational literature.

Firstly, the term "evaluation" may be used in two completely different meanings and contexts, viz.

- (a) evaluation in the sense of judgement, appraisal, assessment and measurement of the effectiveness of the curriculum in all or some of its aspects, and
- (b) evaluation as an intellectual ability to form judgements about the value of material and methods for particular purposes. In Bloom's Taxonomy of Educational Objectives, for instance, evaluation is the highest ability in the hierarchy comprising the cognitive domain.²

Secondly, even when evaluation is restricted to the usage implied by the former of these two interpretations, one finds more than one approach. Evaluation may simply be viewed as the process of gathering data and information on the curriculum content and structure and its application in practice, and the publication of these data and information for possible consumers;³ or it may include, in addition, the interpretation of the data and information, judgements on the effectiveness of the curriculum or parts of the curriculum, and recommendations on curriculum change and improvement.⁴ The latter approach is usually followed when the evaluator, or evaluating team, forms part of the curriculum development group. In this context a distinction should also be made between evaluation for course improvement and evaluation as research on curriculum design and development.

In the third instance, the gathering of data and information may also be approached from two distinct points of view. "One, which might be said to correspond to the idea of assessment, can be described as 'the measurement of the achievement of objectives'. The other... can be summed up as 'the collection and provision of information about an educational situation'.⁵

Lastly, the gathering of the information and the conclusions reached on the basis of the information gathered, may also cover an extremely wide spectrum. Different authors emphasise different aspects within this range, e.g.

- (a) value judgements based on opinions;

- (b) judgement based on descriptive analyses of various aspects such as objectives, content, methods and materials;
- (c) systematic evaluation of the different curriculum elements and of the curriculum as a whole by the application of mainly psychology-derived investigative techniques;
- (d) assessment of pupil performance, usually in terms of expected behaviours, as an indication of the effectiveness of the curriculum.

In each of these areas there may again be differences in approach, e.g. assessment of pupil performance may take the form of pre- and post-tests, criterion-referenced tests or norm-referenced tests.

Much of this variety is due to the rapid development of curriculum evaluation as a specialization within Education and to the high frequency with which new techniques and approaches are applied in order to base judgements on more reliable evidence derived from a broader base than simply pupil performance. In general, however, most modern writers seem to subscribe to descriptions of curriculum evaluation like the following:

Curriculum evaluation is the gathering, analysing, reporting and interpreting of data so as to improve decisions about the elements of the curriculum, namely, the objectives, content, method, organization and the evaluation procedures used in assessing student progress and attainment,⁶ or, in more general terms, "the collection and provision of evidence, on the basis of which decisions can be taken about the feasibility, effectiveness and educational value of curricula."⁷

1.2 Evaluation processes

Three evaluation processes are usually recognized, namely reflective, formative and summative evaluation. A fourth process, illuminative evaluation, has been suggested by Parlett and Hamilton.⁸

1.2.1 Reflective evaluation

This process operates in the initial planning stages of curriculum design. "It is mainly a subjective process, embodying the selection and application of criteria and use of expert opinion..."⁹

Cohen¹⁰ reports that there is a dearth of evidence of significant recourse to reflective evaluation in chemistry curriculum development. This statement is also true of science curricula in general. There is little evidence available of discussions or studies which provide information and guidance to developers of curricula for physical science for making these essential preliminary and initial decisions:

Ad hoc decisions often involving sharp vacillations of existing practices, and frequently reached by small groups of key policy-makers, have had far greater influence than rational discourse. The need continues to exist for regular interdisciplinary discourse, involving chemists with teachers and other educators, philosophers, sociologists, psychologists, students and the community. Such discourse is prerequisite to effective reflective evaluation of curricula.¹¹

1.2.2 Formative evaluation

Formative evaluation takes place during the development of the curriculum, i.e. while the decisions about the different elements, the teaching-learning activities and the supporting materials are not yet "final". Such formative evaluation should, through the appropriate feedback, lead to curriculum improvement and refinement by means of progressive modification of the different curriculum elements.

Formative evaluation data may be obtained by various means such as informal observation, feedback from participating teachers and students, and through highly organized and carefully controlled

pilot trial schemes. Data and information may take the form of test results, formal written reports, visual reports (photographic and videotape records) and audio reports (tape recordings, interviews), or of combinations of two or more of these.

According to Cohen¹² the need for more serious consideration of methods of conducting formative evaluation in order to obtain progressive feedback during the developmental stages of curriculum design is a crucial and neglected one.

1.2.3 Summative evaluation

Summative evaluation is carried out at the end of a unit of work or after a specified period of time to assess the attainment of initial aims and objectives and to identify other possible outcomes. It is thus concerned with the systematic evaluation of the overall effects and effectiveness of the curriculum, or of parts of it, after its implementation. Depending on the criteria applied, summative evaluation should, in theory at least, be able to provide the designers and consumers with information on the feasibility, suitability and effectiveness of the curriculum under certain specified conditions.

In practice, however, a completely different picture emerges. After an analysis and critical discussion of summative evaluations carried out on chemistry curricula (which may also be applied to physics and physics-chemistry combinations such as Physical Science), Cohen¹³ arrives at a very discouraging conclusion:

The dearth of educationally significant evaluation studies must be a cause of great concern. How do we know that efforts to improve chemistry, curricula... are at all effective? Do we need to reconsider chemistry education objectives? Answers to such questions demand carefully designed action research studies... Few curriculum studies venture beyond the traditional, conservative pencil-and-paper instruments and methods. It is inconceivable for

a scientific profession to continue to tolerate such a data-free and evidence-lacking situation. Major efforts must be urgently devoted to improving curriculum evaluation instruments and procedures.

Cooper¹⁴ casts serious doubt on the division made between formative and summative evaluation:

It may be wondered whether this stark division is helpful. Even an evaluation which concentrates on the revision of the programme concurrently with its development... is bound to have a great deal in it to help anyone making a summative judgement on the adoption of the curriculum... In a similar way, an evaluation which is avowedly summative... does in fact make points which, had they been made at the trials stage, would have led to a revision of the curriculum.

He does agree, however, that it is often useful to know at which stage an evaluation was undertaken, and suggests the terms "concurrent evaluation" and "subsequent evaluation" instead. He argues that both types of evaluation should be available to the potential user and that concurrent evaluation should not be limited to the provision of information to the developer only. In the South African context, where syllabuses are prescribed, the latter argument falls away, but it should be pointed out that many of the results of concurrent or formative evaluation identify problem areas which may assist the teacher in the effective implementation of a new curriculum.

1.2.4 Illuminative evaluation

According to its authors, Malcolm Parlett and David Hamilton,¹⁵ illuminative evaluation is rooted in social anthropology and it "seeks rather to describe than to interpret, and takes account of the contexts in which educational innovations must function."¹⁶ The central concepts in this system of evaluation are the instructional system and the learning milieu.

Very little evidence exists about the application of this process to any major curriculum, but it must be pointed out that the fact that it is based on social-anthropological rather than on educational criteria, indicates a fundamental bias and weakness.

1.3 Techniques of curriculum evaluation

The various techniques employed in the different forms of curriculum evaluation are classified and summarised by Steadman¹⁷ as follows:

1.3.1 Formative feedback techniques:

1. Questionnaire and checklists.
2. Teacher diaries.
3. Group discussions and evaluation conferences.
4. Interviews.
5. Pupil opinion and reactions.

1.3.2 Attainment testing:

1. Control group procedures.
2. Pre- and post-testing,

1.3.3 Attitudinal change and motivation:

1. Attitude scales.
2. Checklists and inventories.
3. Osgood semantic differential.
4. Repetory grid tests.

1.3.4 Curriculum context and process:

1. External measures which provide data on the setting of the school: school type, sex, size, area, etc.
2. Case studies.
3. Observation schedules.

4. Interaction schedules.
5. Participant observation (in which the evaluator joins the staff for a period of time).

1.4 Testing, measurement and evaluation

The terms evaluation, measurement and testing are often used as synonyms in the context of curriculum evaluation. Discussions devoted to "evaluation" are often limited to the classification and analysis of various techniques of testing pupil performance,¹⁸ and many research papers are devoted to statistical analyses and interpretations of the quantifiable aspects of evaluation.

In the current literature evaluation is interpreted broadly to include testing as well as other means of measurement and of gathering relevant "soft data" which form part of the complete programme of appraisal required to make judgements and decisions. Testing is but one of the methods of measurement, and measurement, although it has a wider meaning than testing, since it involves other instruments and processes for the collection of quantifiable data, also has a much narrower meaning than evaluation. Both testing and measurement provide only part of the data required of a comprehensive evaluation system.

1.5 The problem of designing criteria for curriculum evaluation

From this introductory summary of the wide scope of curriculum evaluation, the variety of techniques employed, and the different purposes of reflective, formative and summative evaluation, it should be clear that it would be an impossible task to design a single set of criteria which can apply to all aspects of the evaluational process. Not only are the purpose and aims of the different evaluation processes not the same, but they often provide different kinds of data and may require completely different methods of handling and interpreting of the data and information gathered. Reflective evaluation, for example, provides so-called "soft data" and requires reflective interpretation of an educational-philosophical

nature, whereas summative evaluation may provide a major proportion of quantitative or "hard data" which may be handled by statistical methods.

The problem of formulating criteria for curriculum evaluation is clearly reflected in the literature. In publications up to the 1960's such criteria are proposed, e.g. those of Taba¹⁹ and of Saylor and Alexander.²⁰ Whereas Taba set out to devise criteria from first principles, based on her model for curriculum design, Saylor and Alexander's seven criteria are derived from and closely resemble the criteria for learning experiences. In this "early" period one also finds criteria for evaluation, such as validity, reliability, objectivity and consistency, which reflect an emphasis on testing and measurement. Later, with the widening in the scope, methods, techniques and purpose of curriculum evaluation, the formulation of criteria is usually not attempted. This trend has led to evaluation as a "natural activity" - an inevitable process which is natural to all human beings engaged in purposeful activities. According to this view, evaluation is not improved by being formalised, recognised as a separate activity or by being carried out by specialized evaluators.²¹

In addition, curriculum evaluation is required to provide more than information on curriculum design and development only, and many demands are made on this element of the curriculum. This is clearly illustrated by Jerome Bruner's²² "guidelines or philosophy of evaluation":

1. Evaluation is best looked at as a form of educational intelligence for the guidance of curriculum construction and pedagogy.
2. Evaluation, to be effective, must at some point be combined with an effort to teach so that the child's response to a particular process of teaching can be evaluated.
3. Evaluation can be of use only when there is a full company on board, a full curriculum-building team consisting of the scholar, the curriculum maker, the teacher, the evaluator, and the students.

4. Evaluation, in its very nature, is likely to create suspicion and concern in the conventional educational setting where it has a history that is inappropriate to present practice of the kind being discussed here.
5. From time to time the evaluator must design instruction as a means of probing and developing general intellectual skills.
6. A curriculum cannot be evaluated without regard to the teacher who is teaching it and the student who is learning it.
7. Curriculum evaluation must, to be effective, contribute to a theory of instruction.

This encroachment of curriculum evaluation upon the fields of the other sub-disciplines of education, such as philosophy of education, psychology of education and methodology of education, is not unique in modern literature.²³ Curriculum study has obviously grown beyond its defined boundaries and has ceased to operate within, and to derive its perspectives from the sub-discipline to which it belongs - the methodology of education. It is essential, therefore, to determine more precisely what is meant by evaluation as an element of the curriculum model.

2. EVALUATION AS A CURRICULUM ELEMENT

Although there is general agreement that evaluation is an essential component of the curriculum, there is no consensus on the exact nature and scope of this element.

2.1 The unity of the curriculum

A curriculum forms an entity, a unified structure, composed of five elements, viz. aims, content, method, organization and evaluation. In the context of curriculum design not one of these essential elements can be isolated as a separate study without distracting from the unity of the curriculum. Aims and objectives, for instance, may be discussed on an educational-philosophical basis, but in the context of the curriculum the discussion should centre around the practicalities of the curriculum. Furthermore, each of

the curriculum elements is closely linked to, and interrelated with all the other elements, and separate treatment of an element ignores these relationships.

The type of summative or subsequent evaluation, which takes place some time after implementation of a curriculum and which does not provide feedback for improving the curriculum during the design and development stage, does not form part of the curriculum model and cannot, therefore, qualify as an element of the curriculum. Evaluation of this kind has an important role and function in curriculum research, as well as in comparative education, but operates from outside the curriculum itself. The term external evaluation is suggested as a more appropriate description than either summative or subsequent evaluation.

2.2 Reflective evaluation as an element of the curriculum

If one accepts the definition of reflective evaluation as a mainly subjective process involving the selection and application of criteria and the harnessing of expert opinion during the initial planning stages of curriculum design, it would appear as if this process refers more to the design of a model for curriculum development than to curriculum design itself. No theoretical model for curriculum design is complete without well-founded criteria, and for the selection and formulation of such criteria expert opinion must be consulted.

It is thus suggested that reflective evaluation, too, cannot be included in the curriculum element "evaluation", but that it is catered for during the design of the curriculum model. Once a model for curriculum design has been accepted, there is little need for further reflective evaluation. Thus the need, which according to Cohen²⁴, "continues to exist for regular interdisciplinary discourse", really reflects the need for a suitable model for curriculum design.

2.4 Formative evaluation as an element of the curriculum

According to the description of this process given in section 1.2.2, formative evaluation forms part of the actual design process and

thus qualifies for inclusion as an element of the curriculum. The terms formative evaluation and concurrent evaluation each imply a process which takes place during a particular stage - the developmental stage - and is then discontinued. After this stage a new process - summative or subsequent evaluation - is put into operation. However, the elements of the curriculum operate at all times in a dynamic interaction process,²⁵ and evaluation should form part of this continuous process.

It is suggested that during the developmental stage when trials are being conducted and the curriculum design is still fluid, evaluation should take place more intensively than during any other stage of the life of the curriculum, but that the process never stops. What is termed "formative evaluation" is simply a peak period in the process of continuous evaluation. After implementation evaluation continues to provide feedback for curriculum improvement, even though this feedback may only lead to minor adjustments in, say, method of teaching or organization of content. In practice the evaluation data obtained during the stage of implementation will be used by the teacher rather than by the curriculum designer, although the latter will also be involved during revision of the curriculum and curriculum materials.

2.5 The techniques of continuous evaluation

The fifth element of the curriculum is continuous evaluation. Before one can embark on the process of designing criteria for continuous evaluation it is necessary to determine the techniques employed in this process. They will, to a great extent, determine the suitability and validity of the various criteria found in the literature. For the technique of testing one would, for example, be justified in considering the criterion of objectivity, but there could be serious objections to this criterion where pupil opinions are used as an evaluation technique.

2.5.1 The formative stage of continuous evaluation

In this stage the main evaluational process is the application of the criteria, and principles, in the case of methodology, to each of the curriculum elements. Information must also be obtained on whether the application of these criteria operates successfully in practice. This information is obtained through formative feedback techniques, such as those listed in section 1.3.1. The following techniques lend themselves to this stage of evaluation:

1. Evaluation discussions and conferences, with specific attention to the application of criteria and principles.
2. Questionnaires and checklists. These should involve administrators, teachers, pupils and other relevant persons such as employers, university lecturers, etc., depending on the level of the curriculum.
3. Teacher reports, diaries and records. Although these may be difficult and time consuming to analyse, they may provide valuable data and information.
4. Interviews with teachers, pupils and other relevant persons (see 2 above).
5. Observation. This enables the evaluator to see the curriculum in action and to monitor teacher and pupil reaction.
6. Pupil reports, to provide further evidence on pupil opinion and reactions.

2.5.2 The implementation stage of continuous evaluation

All the procedures listed for the formative stage also apply to the implementation stage, but not to the same degree. It would, however, be less disrupting to schools, teachers and pupils to concentrate mainly on those techniques which form a natural and routine part of the daily teaching practice, e.g. teacher diaries and records. It should also be pointed out that evaluation discussions remain important throughout the implementation period. The information fed back by the various techniques would serve little

purpose unless discussions are held in order to determine the reasons for success or failure of any particular aspect of the curriculum-in-action.

In addition, the techniques of attainment assessment are applied at this stage. These include "testing" of attainment of the curriculum objectives relating to skills, knowledge and attitudes. A variety of testing procedures are available:

1. Control group tests.
2. Pre- and post-tests.
3. Criterion-referenced tests.
4. Norm-referenced tests.
5. Attitude scales.
6. Checklists and inventories.
7. Repetory grid tests.
8. Semantic differential techniques.

Here, too, an important, natural source of valuable data exists. By better use of class tests and examinations much important information may be obtained without disrupting the normal school activities. Very little use is made in South Africa of feedback from the analysis of examination answers. That this situation is not unique, was confirmed in the interviews with educationists from five continents.²⁶

2.5.3 The curriculum context

Continuous evaluation may be conducted on different scales.

In a centralized system it would be possible to include all the participating schools or institutions, whereas in other systems it may be advisable to base the evaluation on a representative sample of the users. For some purposes the evaluation may be carried out in individual schools only. Whatever the scale of evaluation may be, it would be essential to determine the context in which the curriculum operates in order to arrive at meaningful

conclusions, to determine the reasons for certain findings, to select a representative sample and to determine the conditions under which the individual curriculum is implemented.

In addition to the techniques listed in section 1.3.4, information should also be obtained on the age, sex, experience and qualifications of the teachers involved.

3. CRITERIA FOR CONTINUOUS EVALUATION

3.1 Criteria derived from the educational literature

Much has been written about the criteria applicable to testing and measurement techniques, but very few authors on curriculum venture to formulate criteria for curriculum evaluation.

Mursell,²⁷ who devotes two full chapters to evaluation in teaching, mentions only two fundamental conditions, namely (a) that evaluation should form an integral part of teaching, and (b) that the learner himself must share actively in the evaluation. These points are also made by Bruner.²⁸

The following are three representative examples of the type of criteria suggested by authors on general methodology and the curriculum:

3.1.1 Saylor and Alexander (1966)²⁹

These authors list the following "criteria for curriculum evaluation".

1. A good curriculum is systematically planned and evaluated.
2. A good curriculum reflects adequately the aims of the school.
3. A good curriculum maintains balance among all aims of the school.
4. A good curriculum promotes continuity of experience.
5. A good curriculum arranges learning opportunities flexibly for adaptation to particular situations and individuals.
6. A good curriculum utilizes the most effective learning experiences and resources available.

7. A good curriculum makes maximum provision for the development of each teacher.

These so-called "criteria" are the authors' ideas of what a good curriculum should consist of and be able to achieve, and are not criteria for the process of evaluation as such. A similar approach can be found in Richmond's The School Curriculum.³⁰

3.1.2 Sterling G. Callahan (1971)³¹

Callahan provides an exhaustive list of "general guidelines" for evaluation. Only those related to the curriculum are given here:

1. Diagnosis is one of the chief concerns of evaluation.
2. When an evaluation procedure does not measure what it is supposed to measure, it is invalid.
3. The accuracy with which evaluation is carried out will help determine its usefulness.
4. Evaluation should be regarded as a continuous program in which attention is focused on balance between... formal and informal procedures.

The remainder of his list of 16 guidelines refers to testing only.

3.1.3 Hilda Taba (1962)³²

Taba's "criteria for a programme of evaluation" are perhaps the best available example of criteria specially devised for curriculum evaluation.

1. Consistency with objectives

"Evaluation must be consistent with the objectives of the curriculum... To develop such a consistency, it is of course necessary that the decisions about any specific part of the evaluation program, such as choosing a particular test or employing a particular method of grading, be made in the light of a perspective on the whole program, and that each instrument of evaluation serve a clear function."

2. Comprehensiveness

"Evaluation programs should... be as comprehensive in scope as are the objectives of the school... The lack of adequate instruments is naturally a great handicap to comprehensive evaluation."

3. Sufficient diagnostic value

"Another important criterion of evaluation is that its results be sufficiently diagnostic to distinguish various levels of performance or mastery attained and describe the strengths and weaknesses in the process as well as in the product of performance."

4. Validity

"Validity, or the capacity of the evidence to describe what it was designed to describe, is even more important in improving curriculum and teaching than dependability and objectivity. If a choice must be made, weakness in the latter may be preferable to weakness in validity."

5. Unity of evaluative judgement

"The evidence secured from different instruments and on different aspects of the evaluation program needs to be brought together into a pattern, so that a meaningful portrait of the individual and of the group is available; otherwise the judgements may be faulty no matter how objective or dependable each piece of evidence is."

6. Continuity

"... Evaluation should be a continuous process and an integral part of curriculum development..."

3.2 Preliminary formulation of criteria

The following ten preliminary criteria were selected and compiled from the literature:

Criterion 1: Curriculum evaluation must be consistent with the curriculum objectives and aims.

Evaluation should not conflict with the clearly stated curriculum objectives, and the content, organization and methods selected to attain these objectives, but should be designed to determine the effectiveness of the curriculum in relation to its objectives.

Criterion 2: Curriculum evaluation must be comprehensive in order to supply data and information on all curriculum elements, including evaluation itself.

The different techniques of evaluation should supply information on the feasibility and attainability of objectives, the suitability of the selected content, the organization of the content and the effectiveness of the methods employed. In addition, inconsistent data on any aspect provided by different evaluation techniques, may reflect on the evaluation itself.

Criterion 3: Curriculum evaluation should utilise all the agencies and persons involved, including teachers and students.

Curriculum, design and implementation involve the design team, the evaluators, the teachers who have to implement it as well as the pupils whose learning is guided and directed by the curriculum.

Criterion 4: Curriculum evaluation should be diagnostic in order to identify possible strengths and weaknesses and to indicate the possible reasons for such strengths and weaknesses.

An evaluation system which only indicates success or failure without being able to provide pointers as to the reasons for these outcomes, is of limited value in curriculum design and development.

Criterion 5: Curriculum evaluation should provide valid evidence.

Validity in curriculum evaluation means that the evidence should describe what it was designed to describe (Taba) and that the evaluation technique or instrument is appropriate to and can provide the kind of information that is required.

Criterion 6: Curriculum evaluation should have a structural unity.

The evidence gathered should not be interpreted only with respect to any single aspect or element of the curriculum but should also be weighed in the light of the interrelationship between the elements.

Different kinds of data and information should be correlated and compared in order to obtain a meaningful overall picture. In addition, more than one instrument or technique should be applied to the evaluation of any area of the curriculum to enable the evaluator to look at the same problem by different methods.

Criterion 7: Curriculum evaluation should be a continuous process which forms an integral part of curriculum design and development.

This criterion refers to evaluation as an element of the curriculum and not to external evaluation for research purposes.

Criterion 8: Curriculum evaluation should form an integral part of classroom teaching.

Criterion 9: Curriculum evaluation should be objective, both in the methods used and the interpretation of data and information.

Criterion 10: Curriculum evaluation should use methods to determine the reliability (dependability) of the data and information in order to make judgements with a high degree of confidence.

3.3 Refinement of the criteria

3.3.1 The criterion of consistency with aims and objectives

This criterion is mentioned and supported by Taba,³³ Saylor and Alexander,³⁴ Nicholls and Nicholls,³⁵ Wilhelms,³⁶ and others.

Wilhelms formulates this criterion as follows:

"Evaluation must encompass every objective valued by the school", and adds:

The obligation is virtually a moral one: Whenever an institution commits itself to any purpose, it takes on the obligation to keep finding out how well it is achieving that purpose, otherwise it cannot improve its efforts. The obligation is also a pragmatic one: Unless the school keeps trying to find out how well it is succeeding with a purpose, the purpose itself is likely to atrophy.

Parallel with the shift in emphasis in science teaching from "education in science" to "education through science", as well as similar tendencies in other subject areas, objectives-based evaluation has fallen into disfavour among some educationists. This has led to the so-called "goal-free" evaluation. The author of this term is Scriven³⁷ who states that for the purpose of evaluation any distinction between intended and unintended outcomes is irrelevant. He concludes that

...consideration and evaluation of goals was an unnecessary but also a possibly contaminating step. I began to work on an alternative approach - simply, the evaluation of actual effects against (typically) a profile of demonstrated needs in this region of education. I call this Goal-Free Evaluation.

According to Scriven the curriculum designers should formulate their objectives in testable terms but should not disclose these objectives to the evaluator, who should be looking for all outcomes, unbiased by whether they were originally intended or

not. According to Harlen³⁸ this kind of approach has led to the type of evaluational strategy suggested by Parlett and Hamilton, namely illuminative evaluation.³⁹

These objections to objectives-based evaluation must be rejected if the evaluation system is to report on all elements of the curriculum - including objectives - and if immediate feedback is required to bring about changes and improvements. It is realised that goal-free evaluation implies a more unbiased approach to evaluation of possible curriculum outcomes and may, as such, have certain distinct advantages. This type of strategy, however, may well form part of external evaluation, but not of continuous evaluation as an element of the proposed model for curriculum design.

Similar arguments to those of Scriven, Parlett and Hamilton were offered by the curriculum workers interviewed.⁴⁰ According to Tawney⁴¹ arguments of this nature are a reaction against the view that educational purposes can profitably be stated through behavioural objectives, and the psychometric tradition of behaviourist psychology. He does not reject objectives-based evaluation as an aspect of the total evaluational programme and advocates a "position between the scientific and natural approaches".

The position is clearly summarised by Steadman⁴² where he states that evaluation of the attainment of objectives

... has fallen into disfavour in recent times in a manner that might not unfairly be attributed to changes in educational fashion. The aversion to such testing in an evaluation context is very misguided, as it relates to that no longer existing situation when such tests alone provided the criterion of successful innovation. Today, evaluators can set the results of attainment tests in a rich context of other information and this aversion to the use of tests is rarely justifiable.

The criterion of consistency with aims is thus accepted since without this criterion a fundamental element of the curriculum which effects all the other elements, cannot be properly evaluated.

3.3.2 The criterion of comprehensiveness

This criterion, too, receives widespread support in the literature. Wilhelms⁴³ formulates it as follows:

The best guide to curriculum improvement is evaluation; and to be an adequate guide the system of evaluation has to be as "big" as the purposes of the curriculum development itself.

Curriculum workers interviewed by the author also agreed to this criterion but some pointed out the practical difficulties in obtaining useful information on all aspects of the curriculum. In this regard information on the application of suggested teaching methods by participating teachers was specially mentioned.⁴⁴

One suggestion was that the criterion of comprehensiveness should include the full range of curriculum elements and activities as well as the full complement of everyone involved in the design and implementation of the curriculum. This aspect is discussed in the next section.

3.3.3 The criterion of utilization of all persons and agencies involved in the curriculum

Bruner's support for this criterion was mentioned in section 1.5. That a large variety of different people may in actual practice be involved in comprehensive curriculum evaluation is also evident from Steadman's⁴⁵ description of the various techniques of evaluation. This criterion is not only supported by educationists but is also applied in curriculum evaluation.

The suggestion, mentioned in the previous section, that this criterion should be incorporated into the criterion of comprehensiveness, seems to be a logical one. Criteria 2 and 3 are thus combined and reformulated as follows:

Curriculum evaluation must be comprehensive

- (a) in that it should collect and supply information on all curriculum elements and activities and on the curriculum as a whole; and
- (b) in that it should involve all groups concerned with the curriculum - specialists, designers, implementers and consumers.

3.3.4 The criterion of diagnostic value

In the context of the curriculum model this criterion is a sine qua non and is thus accepted without further discussion.

3.3.5 The criterion of validity

Validity is generally regarded as the most fundamentally important quality of an evaluational procedure, hence it is paradoxical that validity seems to be the criterion that designers of evaluation programmes have been least successful in achieving.⁴⁶ When evaluation moves beyond measurement, as in aspects of curriculum evaluation, validity is even more difficult to achieve.

In the context of curriculum evaluation, validity ought to be defined broadly to "encompass any basis for defending the (procedure) as a measure of what it claims to measure".⁴⁷ Ebel⁴⁸ suggests that such a broad definition is that which is stated in Webster's New Collegiate Dictionary: Evaluation is valid if it is "founded on truth or fact; capable of being justified, supported or defended; well grounded; sound". According to Ebel such a definition does not require that validity must always be expressed as a co-efficient of correlation. "It does not imply, as some writers on validity have seemed to imply, that only really acceptable evidence of validity is quantitative". Some problems of determining the validity of evaluation based on classroom observations and a discussion of the validation procedures that may be used, are outlined by Millar.⁴⁹

The problem of validity is closely related to other aspects of achieving some rigour in curriculum evaluation, such as objectivity

(Criterion 9), reliability (Criterion 10) and consistency. It is proposed that these criteria be combined into a single statement which incorporates all these aspects:

Curriculum evaluation should be as rigorous as is practically possible in terms of validity, objectivity, reliability and consistency.

This may be achieved by using statistical methods where appropriate, but also by the application of other methods such as those suggested by Tawney:⁵⁰

1. Triangulation: Evaluating the same element, item or problem by using different methods.
2. Publicity: Immediate and continuous reporting of the results and interpretation in order to obtain appropriate comments and criticism.
3. Reiteration: Redesigning evaluation procedures and reformulating interpretations in the light of comments and criticism of first efforts.

The point of view offered here is perhaps best summarised in the words of Steadman:⁵¹

When data have been obtained informally, it is not always possible to offer reassurance of adequate reliability even in the technical sense. Evaluators should be ready to admit this and to offer instead the amalgam of reliability and validity data which inquirers often have in mind. The validity of even informally obtained views is open to confirmation if a proper programme of cross-checking has been incorporated into the evaluation and the context of events is adequately delineated.

3.3.6 The criterion of unity

The unity of the curriculum is constantly emphasised by educationists. Thus, Hooper⁵² states:

The important thing is that the... key curriculum questions cannot be answered sequentially as is so often assumed in speeches about the curriculum when the teacher is requested first to state his or her objectives. Effective curriculum design requires an iterative process, where each question is constantly being reprocessed in the light of answers to subsequent questions.

This statement is echoed by Bruner:⁵³

For a curriculum is a thing in balance that cannot be developed first for content, then for teaching method, then for visual aids, then for some other particular feature.

This unity, as is evident in the indissoluble relationship among the five curriculum elements, thus also applies to evaluation. For it is evaluation in particular which has to supply information on all aspects of the curriculum and which provides the feedback for decisions about curriculum change and improvement. Without the imposition of this criterion the suggested model for curriculum design loses its unity and breaks down. Unity in evaluation leads to a recycling of the process of curriculum design, incorporating improvements and changes based on the information gained and the decisions suggested by this information.

3.3.7 The criterion of continuity

Curriculum evaluation, as an element of the curriculum and distinct from external evaluation of the curriculum, has been defined as continuous evaluation. The arguments for this definition make up the major part of Section 2 of this chapter. Therefore, since this criterion is implicitly included in evaluation as a curriculum element, a separate statement in this regard would be superfluous and repetitive.

3.3.8 The criterion of integration with classroom practice

From the discussions and arguments in Section 2 on EVALUATION AS A CURRICULUM ELEMENT it would be obvious that not all aspects of the total evaluation process can be integrated with actual classroom activities. The formative phase of continuous evaluation, for example, initially required techniques which cannot be derived from teaching practice. Bruner's⁵⁴ statement in this regard seems to take this problem into account when he specifies that "Evaluation... must at some point be combined with an effort to teach".

Bruner, however, does not carry the argument far enough. Curriculum is not an esoteric educational study but, as a component of the methodology of education, it is concerned with teaching and learning, and as such the evaluation element should also be directed towards making judgements about the effectiveness of the curriculum-in-action.

In addition, it should be pointed out that evaluation which interferes with regular classroom activities and routine, may have a detrimental effect on the teaching-learning situation and consequently on the evaluation itself. Any outside influence acting on a system tends to distort that system, and will yield results pertaining to the distorted and not the normal system. This is one of the grave dangers of an external evaluation which interferes with normal teaching-learning activities.

In order to provide for these two aspects, the criterion is reformulated as follows:

Curriculum evaluation should be directed towards and be focused on the practical teaching situation and, when it involves implementation, be integrated with the classroom teaching in order to prevent distortion of the teaching-learning activities.

3.3.9 The criteria of objectivity and reliability

These criteria are incorporated into the more general criterion of maximum obtainable rigour in evaluation, introduced in Section 3.3.5 above.

3.4 The final formulation of the criteria for evaluation

From the original list the following six criteria for continuous evaluation are thus retained:

1. The criterion of consistency with curriculum aims and objectives;
2. the criterion of comprehensiveness (a) in terms of breadth of coverage of aspects of the curriculum, and (b) in terms of involvement of the different groups concerned with curriculum design and implementation.
3. The criterion of diagnostic value.
4. The criterion of maximum obtainable rigour in terms of objectivity, validity, reliability and consistency.
5. The criterion of unity in evaluation.
6. The criterion of relatedness to practical teaching.

It should be emphasised that these criteria apply specifically to continuous evaluation as an element of the model for curriculum design, and not to evaluation in general or to evaluation for specific or specialized purposes. They should not be compared with the criteria generally cited for evaluation of student achievement. Although the attainment of the pupil is perhaps the most important single measure of the success or failure of the curriculum, the reasons for success or failure cannot simply be related to student ability and effort. The measurement of pupil attainment is one parameter of the process of evaluation, and provides part of the information and evidence required for sound educational judgement. The criteria do not necessarily and self-evidently apply to the parameters and components of the evaluation system, but to the system itself.

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