A SYSTEMS MODEL FOR TRAINING

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Introduction

'Train 1500 instructors in six weeks? You must be crazy! It can't be done. You will simply be lowering our standards.'

This was the first, instinctive reaction of the staff of the South African Defence Force College for Educational Technology on hearing the request of the Officer Commanding, the School of Infantry at Oudtshoorn that they train his National Service junior leaders as instructors. At first sight the request did seem to be entirely unreasonable, but after some quiet consideration it was seen as a tremendously exciting challenge to educational technology. The gauntlet, which had been thrown down by the School of Infantry, was taken up by the College.

The Need for Instructor Training

It is common knowledge that, in the Republic of South Africa, the South African Defence Force has the responsibility for the development in more than 30 000 persons per annum (South African Defence Force Personnel Statistics 1978) of the skills demanded by modern warfare. The majority of these persons, having been scholars, have had no previous training for work. To conduct this training the South African Defence Force uses more than 800 Permanent Force Instructors and some 2 500 National Service Instructors.[1]

In contrast to the extensive training of professional teachers, the training afforded these Defence Force instructors must, by the very nature of modern warfare and the limited time available for training, be of the shortest possible duration. In addition to proficiency in the skills which they are required to reach, these instructors need to acquire certain didactic skills in order to be able to execute their job – the training of other adults.

The continuous evolution of sophisticated weapons since World War II has increased the needs of armed services for highly trained, technically competent personnel and for trained instructors (Decision System Associates Document p 1). The rapid changes occurring in education[2] the vast array of instructional material available[3] and other similar developments, however add to the increasing difficulty experienced by instructors in controlling and using to the optimum the myriad of changes and advances occurring with great rapidity in their chosen field.

Similar considerations apply equally to the nation as a whole when the number of potential workers in the Republic (and the consequent need for the training of instructors and workers) will increase by approximately 286 000 during the ten years 1973 to 1983[4]. With these factors in mind, as well as the nature of the times which beset the Republic it is evident that improvement in the means of developing the skills of these instructors can contribute both to the safety of the Republic and to a reduction in the inevitable military burden on the economy.

With this as background therefore it became obvious that the challenge presented by the School of Infantry could, if met, provide a means for the more effective handling of other forms of training in the Defence Force and possibility in the Republic.

Changes Occurring in Educational Technology

In the past twenty years there have been more significant changes in education (and in educational technology) than ever before in the history of education (National Committee for AV Aids 1971 p 1).

These changes have had a profound effect both upon the instructor and the student as well as upon the effectiveness and efficiency of teaching. The South African Defence Force has not been left untouched by these changes, which have ranged from a proliferation of materials and aids available to the instructor and student, through changes in the role of instructor and student to changes in the very environment in which learning takes place. As Michael Rossman[5] says 'Change is the name of our age and our culture'.

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1. Chief of Staff Personnel: *Report on a Survey into Education Technology in the SADF*, p 2.
2. S.C.W. Duvenhage: *Die opstandige student*, p 1 – 5.
3. A.J. Romiszowski (ed): *The systems approach to Education and Training*, chapter 2.
4. W.J. de Villiers: *Principles of Decentralised Management*, p 7.
5. S.C.W. Duvenhage: *op. cit.*, p 1 – 5.

Most teachers (and instructors) have met or have heard of programmed tests, overhead projectors, 8mm, and 16mm projectors and cameras, automatic slide projectors and episcopes, television cameras, monitors, projectors, as well as special-to-type equipment for teaching specific subjects ranging from astro-navigation to welding.

The teacher is being displaced from his traditional role to that of preparer and manager of an information processing system[6], in which role he must use to the best advantage the variety of media and methods available to him.

The environment in which learning takes place, remembered by most military men as a classroom furnished with uncomfortable chairs and a blackboard, has given way in many cases to purpose-designed teaching-learning spaces which modern furniture complements, a pleasing decor in which appear a host of technological aids to the teacher[7].

Obviously, these changes have not yet permeated throughout the Defence Force, and there are necessarily many examples of traditional instruction and traditional classrooms. There is however emerging an awareness of the complexity and the promise of educational technology and of the difficulty experienced by instructors and those in charge of training in mastering and using this promise.

Steyn[8] puts into words the unspoken need of the trainer when he says there is a requirement for 'the development of a systematic approach to the educational process which considers the relationships between specific aims and objectives, attitudes, instructional requirements and the assessment of performance.'

The Systems Approach

It can be argued, on the one hand, that the systematic approach to teaching and learning such as that advocated by Steyn is nothing new, and that good instructors have for years used existing knowledge about learning, or have been careful to formulate their aims, try out various methods and assess the results. On the other hand the complexity of the present situation needs something more than common sense; it requires the use of specialized techniques within a consistent overall framework. The systems approach provides just such a framework.

The term 'systems approach' is not new to the Defence Force, having been applied in a variety of fields and more specifically in training since 1969.

The term Systems Approach is used in so many contexts that it is difficult to assign a meaning that is not so general as to be virtually useless. Most authors agree however that the concept includes formal problem solving[9].

Despite the disagreement concerning the clear definition of the systems approach, it has evolved as an approach to the general problem of organising resources to accomplish tasks which uses the principles of general systems theory. The existence of a set of principles applicable to systems in general makes it easier to study existing systems and apply the findings to the development and design of other systems, and to the solution of dissimilar problems[10].

System for the Development of a Training Course.

Using the systems approach, a systems model was developed by the author to enable an instructor to plan, prepare for and implement a training course, thereby exerting a greater degree of control over and (hopefully) extracting some of the promise of educational technology[11].

The systems model consists of four subsystems. In this simplified diagramme (Fig 1) the relationship of the four subsystems one to the other is indicated. The four sub-systems are:

a. *Analyse requirements.* This consists of identifying the manpower needs;
analysing the jobs;
and deriving the personnel specifications.

b. *Specifying the contents of training.* Consists of deriving the training needs;
writing the training objectives;
sequencing the objectives;
and preparing the criterion tests.

c. *The process of instruction.* This consists of selecting the teaching strategy;
designing evaluation measures;
a field test of the strategy;

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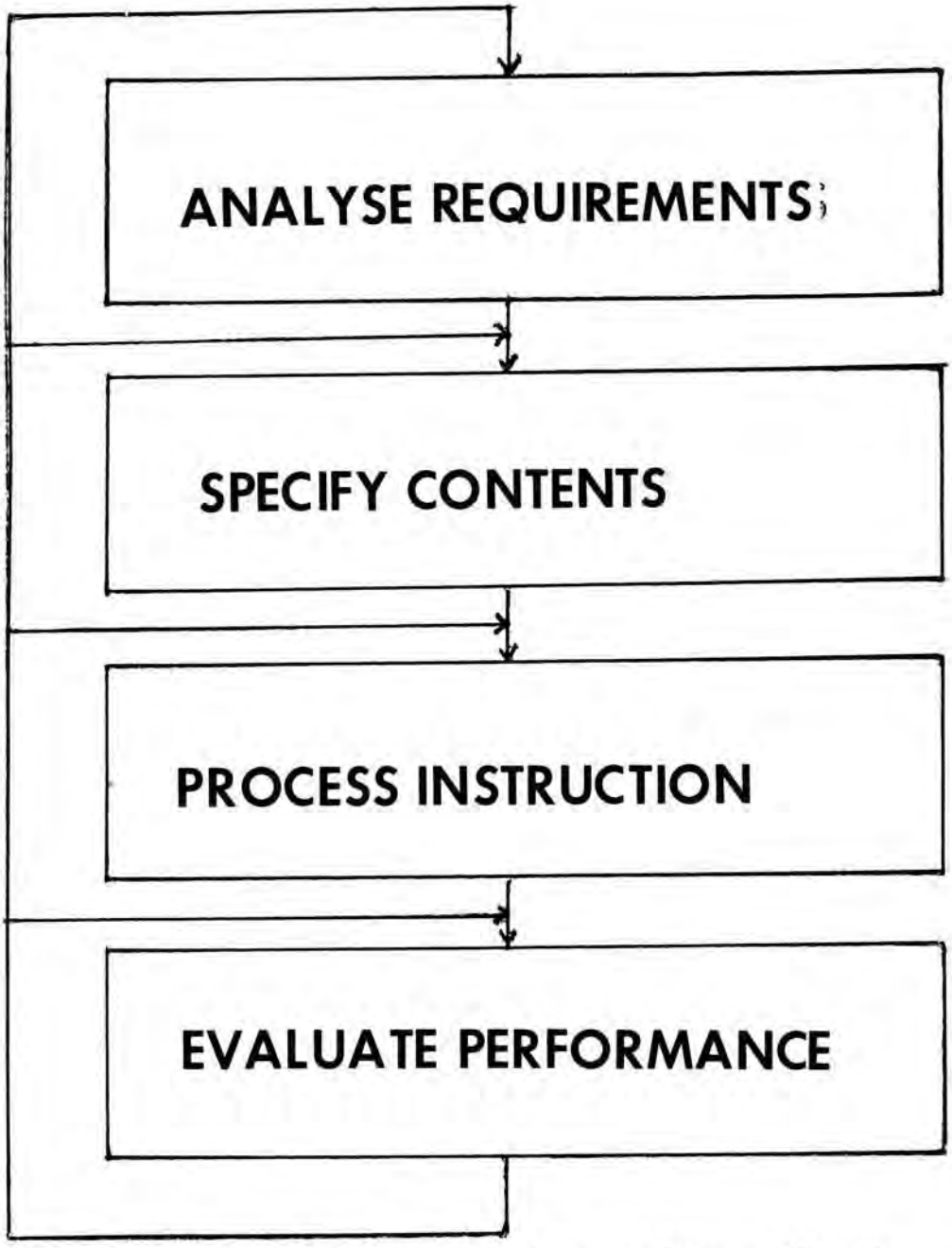
6. W.P. Janssen: *Moderne Onderwijsmiddelen in de praktijk*, p 81.
7. A.C. Green (ed): *Educational facilities with new media*, chapter 2 – 3.
8. G.H.A. Steyn: *University Didactics* (Occasional Paper 1975), p 6.
9. J.E. Bratten: *A systems approach to the improvement of instruction*, p 161.
10. *Educational Technology Review Series* no 3, 1973. (T.A. Ryan: Systems Techniques for Programs of Counselling and Counsellor Education), p 49.



A1 Model of System of Development of a Training course: Subsystem Relationship.

and the implementation of the approved strategy.

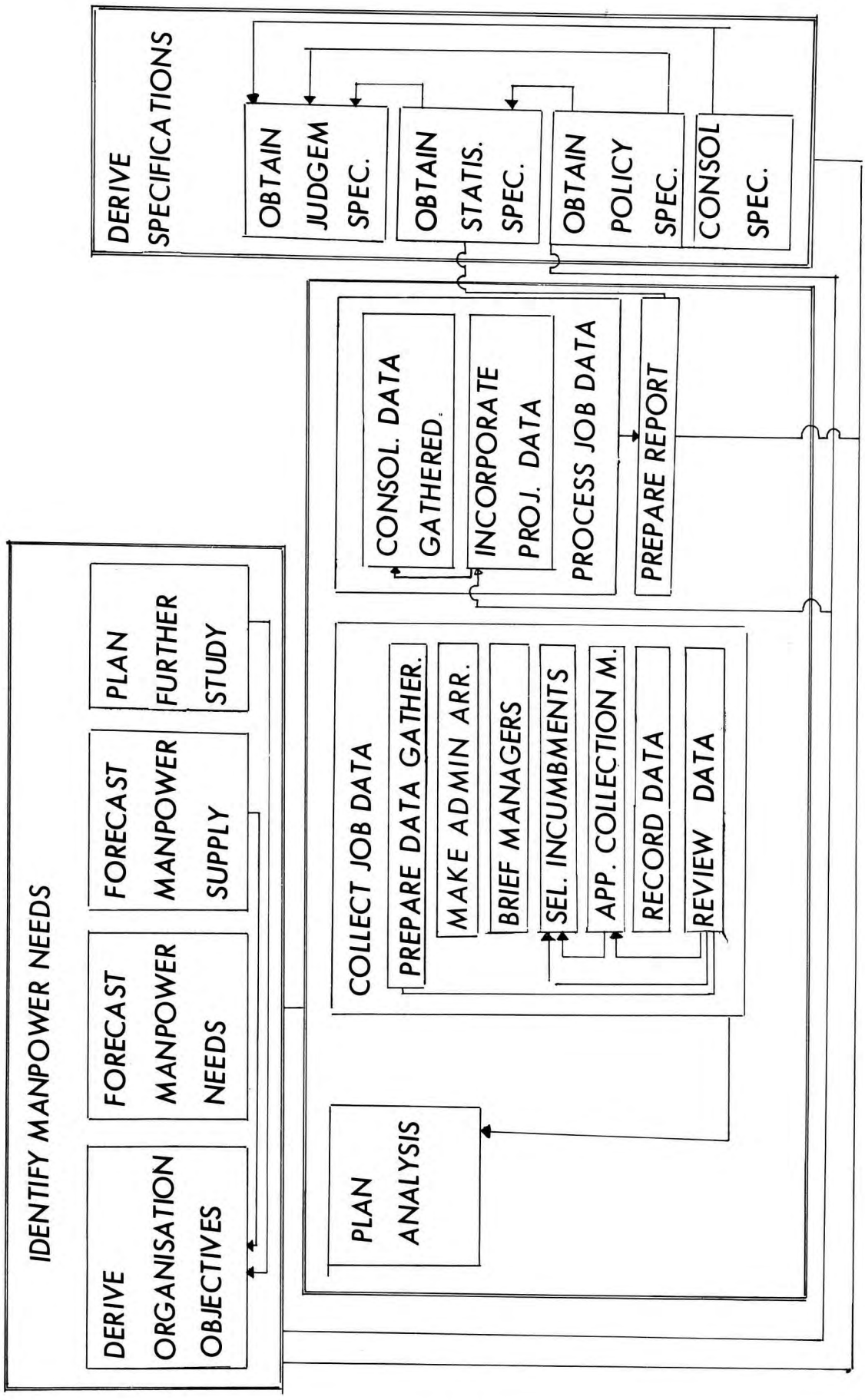
d. *Evaluation of performance.* In this subsystem one evaluates the sub-system achievements;
job performance;
the systems effectiveness;
and then one analyses the date obtained and takes the necessary correcting action.

The original systems model for developing a training course consists of 82 elements which are joined by 64 signal paths, and which require information to be fed back or fed forward 23 times. Space precludes the inclusion of the total system model therefore simplified versions of each of the sub-systems will be shown and discussed.

The analysis sub-system. (Fig 2)

In this sub-system one is required to identify the manpower needs, analyse the necessary jobs, and derive personnel specifications.

Since it is not usually the task of the instructor to derive the organisation's objectives but merely



A2 The Analysis Subsistem.

to ensure that his training is aimed at meeting these objectives, and to see what effect the objectives will have upon his plans for training, he requires only to identify the objectives (1.1.1). In forecasting manpower needs the teacher once again identifies the categories of manpower needed, and quantifies these (1.1.2). In forecasting the manpower supply, the sources to meet the needs are projected (1.1.3). Inability to supply in particular categories and quantities may require that the company's objectives be altered, and the cycle recommenced, hence the feedback loop. (1.1.4) The instructor's interest here is centred around the effects of the sources of supply on his training and development plans. With this information the instructor may derive the plans for training and development which are necessary to meet the company's objectives. It is essential that the adequacy of the plans and the activities resulting from these plans are evaluated. The information from the evaluation is fed back to the organisation's objectives so that the alterations and a further iteration of the cycle can be commenced if necessary. The output from *identify manpower needs* becomes the input to *analyse jobs*.

The analysis of the job to be performed forms the basis of the training which follows. Initially the analysis is planned and the information derived used to collect the job data necessary (1.2.1) Tracey[12] discussing primarily the observation and interview methods of collecting job information indicates six major steps which need to be taken. These are: prepare data-gathering instruments; make administration arrangements; brief the managers; select the incumbents; interview the incumbents; and record the data. Baer[13] advocates essentially the same steps but adds an additional important step: review the data obtained.

At this stage the information collected is in the form of descriptions of individual jobs, or in large groups of data still requiring sifting and sorting into manageable proportions[14].

The process to which it is subjected is designed to enable the performance desired of the trained man to be derived, and the characteristics of the individual man upon whom selection is based to be identified.

The information is therefore consolidated so as to define the limits of the jobs, and to define the aspects such as the criticality of the tasks, the frequency of performance, level of difficulty and so on (1.2.3)[15].

The information available represents the job as is, not as it should or will be performed. Any training program based on such information is thus likely to be defective. It is necessary therefore to consider the probable impacts of known changes, changes which have taken place since the job was devised and which have not been implemented, or for which the incumbents were not prepared. A major source of projected information is the organisation's objectives and long and short range forecasts[16]. The incorporation of projected and known changes may cause the consolidated data to require change, until a stable position is reached.

Finally the formal written report is generated from the processed data, with the purpose of informing all the interested personnel of the conclusions reached, providing a record of the findings and providing a basis on which further action may be taken (1.2.4).

For any given job, the combinations of work activities, work environment, and other related factors imply the *job requirements* of the job. These are in effect the characteristics required of the incumbent if he is to perform the job successfully. To ensure the most effective use and development of people; to ensure that the methods of assessing performance, motivating and rewarding people are adequate and equitable, to assist in the establishment of job satisfaction,[17] personnel specifications need to be set (1.3).

There exist in essence two methods of establishing these personnel specifications, namely by judgement and by statistical method, the objective in both cases to make predictions of job success on the basis of information about the personal characteristics of the incumbents[18].

A factor which needs to be taken into account when setting personnel specifications is the organisation's policy. It may for instance be policy that, despite individual ability only specified race groups may be employed in certain categories; additionally

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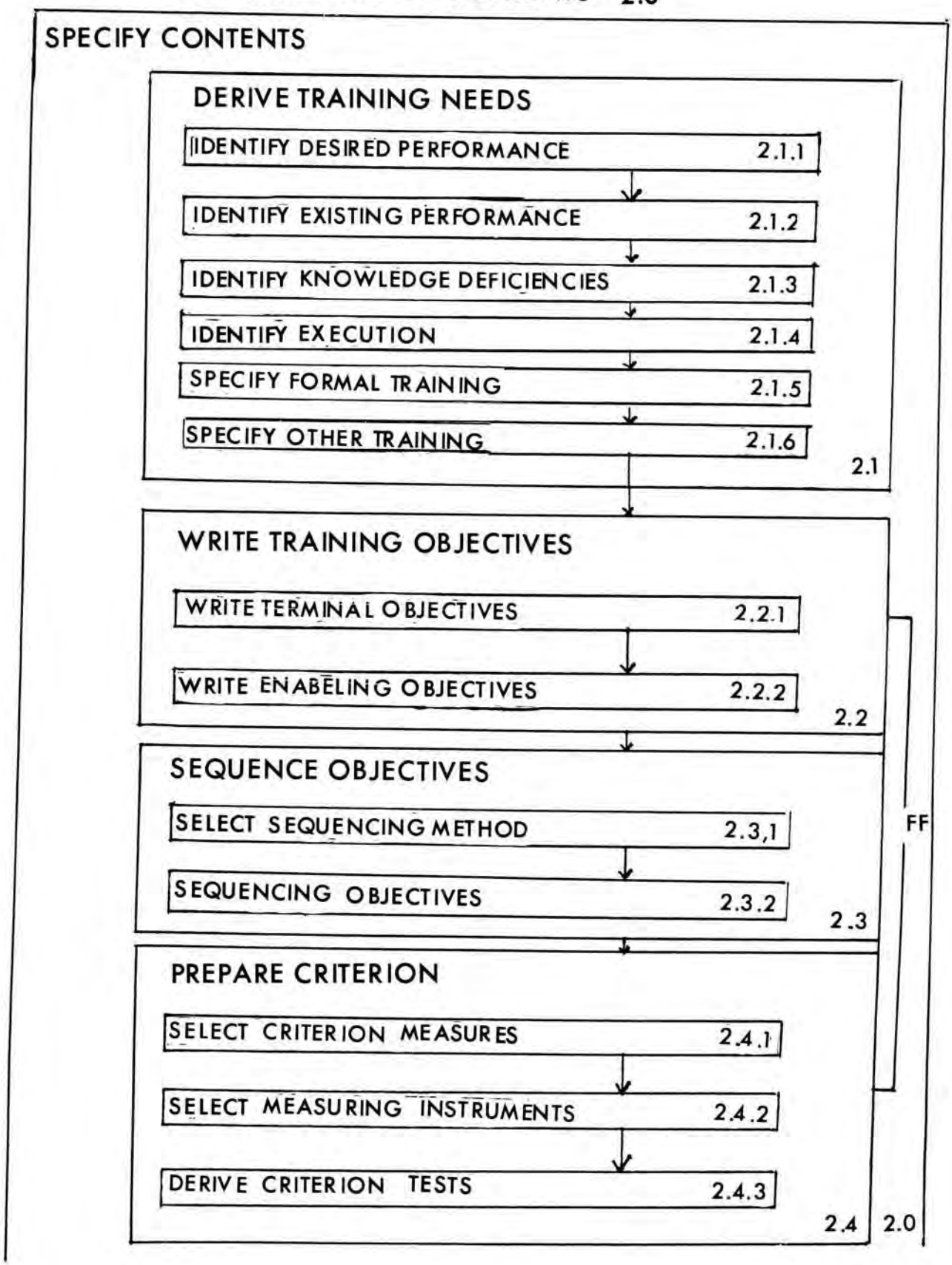
11. R. Eberlein: *A Didactical model for the Job-oriented Training of Adult workers.*
12. W.R. Tracey: *Designing Training and Development Systems,* pp 52 – 69.
13. In *Organisation for European Economic Co-operation,* pp 49 – 57.
14. W.R. Tracey: *op. cit.,* p 72.
15. *Ibid.,* p 71; I.K. Davies: *The Management of learning,* p 46.
16. W.R. Tracey: *op. cit.,* p 72.
17. J. Finnigan. *The Right People in the Right Jobs,* p 10 – 21; W.R. Tracey: *op. cit.,* p 70.
18. W.R. Tracey: *op. cit.,* pp 68 – 78.



A3 The Content Subsystem.

notice needs to be taken of such factors as the legal aspects governing employment of certain categories of personnel, such as women, minors etc.

According to Tiffin and McCormick[19] it is preferable to draw upon all the sources of information about personnel characteristics, then consolidate the information in drawing up the final specification. This obviously is going to require the making of compromises and the adjustment of the information gleaned from the various sources in arriving at an equitable solution.

The feedback arrow between *Deriving Personnel Specifications* and *Identifying Manpower Needs* indicates that it may be necessary to modify the manpower needs specified by the organisation in terms of specifications of personnel required to perform the job, and vice versa.

The content sub-system (Fig. 3)

One might suppose that having derived the detailed tasks to be performed in the job, one merely transposes these into the form of objectives, and sets about teaching these. That might be so were one able to assume that the student knew nothing whatsoever about the job and that that (the job) was all that he needed to know. Every adult, however, has in his repertoire some knowledge which has been developed in him on his way to adulthood. To ignore this existing knowledge would, at the very least, be an affront to his dignity as a human being.

In deriving that which needs to be taught (in job-oriented training parlance, the training need) one subtracts from the desired performance that which the student is already capable of achieving.

In reading the last statement it is as well to remember that not all deficiencies in performance are caused by a lack of training. As Davies says, '*Whenever a problem involving a deficiency in knowledge, skill or attitude exists, it is all too easy to fall into the trap of thinking that some form of formal training program is necessary.*[20].

One effectively needs to consider six aspects concurrently in deriving the training needs (2.1). These are:

The desired performance
The students' existing performance
Deficiencies in knowledge
Deficiencies in execution
Formal training needs
On-the-job and other training needs.[21]

Considerable attention has been paid in the literature to the need to specify the results desired after training in terms of objective statements of student performance. One of the best known works is that of Mager[22]. The training objectives specify the terminal performance required of the student in terms of the task to be performed, the standard of performance required and the conditions under which the performance is expected.

While these terminal objectives are stated in considerable detail it is hardly sufficient to determine exactly what the content of the course a student to be able to type at a certain speed for a certain period of time at a specified accuracy does not reveal the need to be able to insert paper in the machine, make erasures and so on. Nor does it indicate the essential aspects of the theory of operation of the machine for example, that might be required. Stevenson[23] used enabling objectives which were extracted from the sub-tasks identified to provide the content of the course.

The amount of theory needed can, according to Gilbert[24] be limited to only that which is necessary by distinguishing between and applied two types of theory. These are realm, and domain theory.

Thus, after stating the terminal objectives, one should derive the content, or interim or enabling objectives (which include the necessary theory) by means of which the terminal objectives may be reached (2.2).

Sequencing, as discussed earlier, is the process whereby the objectives are placed in the optimum order for learning. In this way one ensures that the necessary supporting knowledge and skills are developed before particular terminal objectives are achieved. There are a variety of methods available for Sequencing, ranging from the well-known 'concrete to the abstract', to a more elaborate system such as Gagne's Hierarchy (2.3).

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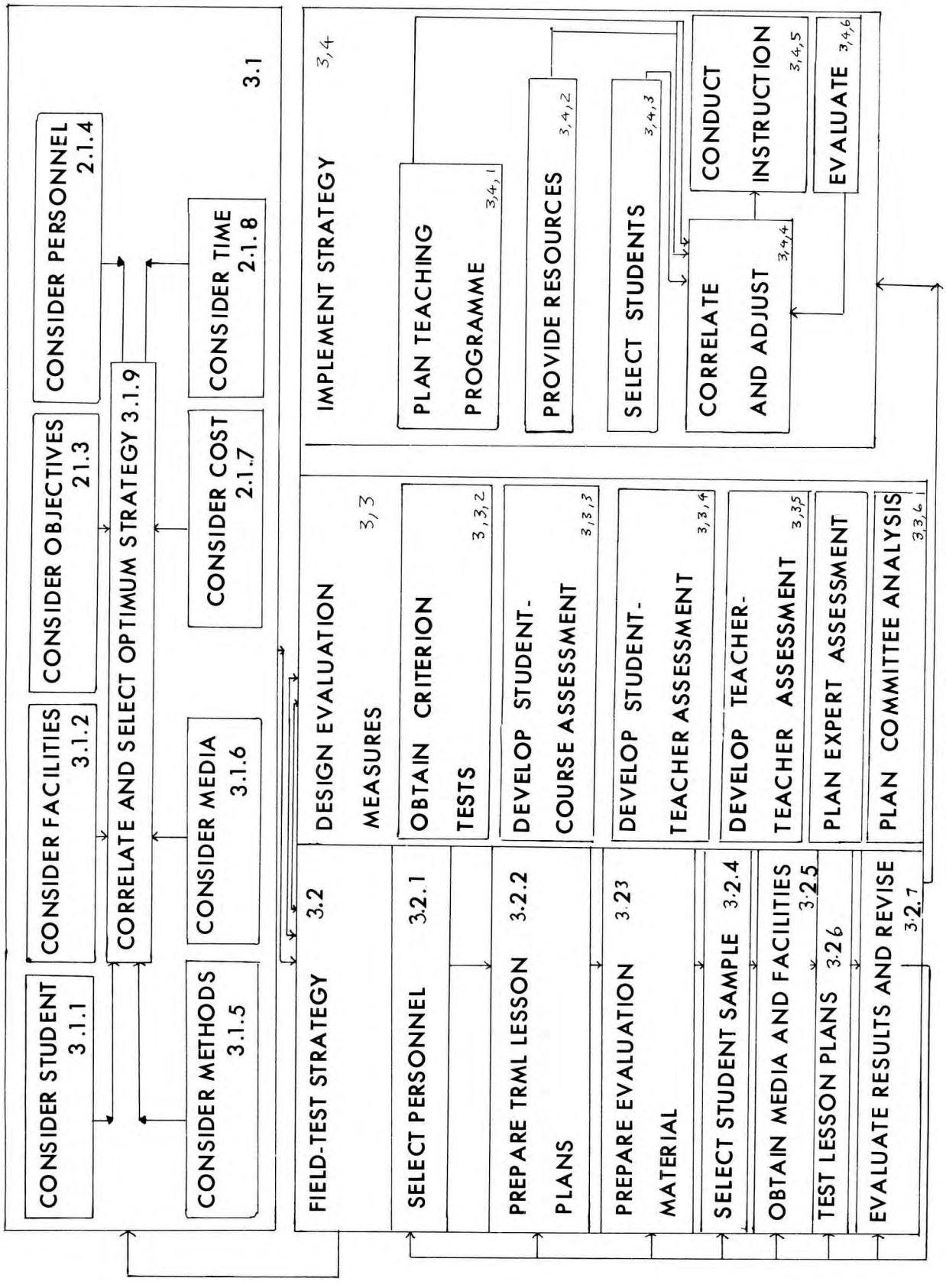
19. J. Tiffin and E.J. McCormick: *Industrial psychology*, p 68.
20. I.K. Davies: *op. cit.*, p 58.
21. R.F. Mager and K.M. Beach: *Developing Vocational instruction*, p 28: *Journal of Mathematics*, vol 1, 1962 (T.F. Gilbert; Mathematics: the technology of education), p 12; W.R. Tracey: *op. cit.*, p 77; A.J. Romiszowski: *op. cit.*, p 37.
22. R.F. Mager: *Preparing Instructional Objectives.*
23. A.J. Romiszowski: *op. cit.*, p 40.
24. Quoted in I.K. Davies: *op. cit.*, p 67.



A4 The Instructional Process Subsystem

Several writers such as Mager and Beach,[25] Tracey[26], Davies[27], and Stevenson, who probably influenced by early programming technique, advocate the development of the criterion tests once the objectives have been finalised. The rationale of this is not difficult to accept, since once the teaching has been commenced it is all too easy to deviate from the set objectives. Were the criterion test compiled after this then it is possible that the influence of this deviation would show itself in the test. The test would then measure what had been taught, and not necessarily what should have been taught (2.4).

The instructional process subsystem. (Fig. 4)

There are complex interrelationships between all of the components of the teaching situation. The number of teachers needed, for example, is related to the ability of the teachers, the contents of the teaching, the number and type of students, the presentation media available and so on. In turn the presentation media required is related to the money available, the abilities of the teacher, the facilities and so on[29]. In deciding the combinations of these that are necessary to achieve the training objectives, one needs to consider all these interrelationships and in some way reach a compromise which will suit the particular circumstances and the particular time. That is the task of this sub-system. Both Gropper[30] and Tracey[31] feel that selection of strategy is based only in part on validated findings, in part on rational objective analysis, and in part on a knowledge of the state of the art. Strategy selection cannot thus be reduced to a simple procedural task. All too often strategy selection is based on expediency rather than on need.

The aspects affecting the selection of a teaching strategy include the student characteristics; the facilities availabe; the objectives; the personnel characteristics; the methods available, the media available; the cost; and the time (3.1).

No doubt can be expressed about the desirability of validating the decision to select a particular strategy by testing it out on a small scale prior to general implementation (3.2), as advocated by Davies,[32] and Gropper [33]. The practical implication of obtaining representative samples of students, the development of trial lesson plans and the like, however mitigate against successful validation.

Validation, at this stage, is aimed at checking the correctness of the decisions concerning the combinations of students, facilities, objectives, personnel, methods, media, cost, and time. The field test is not aimed at testing the achievement of every objective, media and method. This would be an unnecessary task and would virtually entail total duplication of the training effort. What is aimed at is the validation of those areas where doubt exists as to their effectiveness. As Rose and Van Horn suggested, in speaking of the production of media, field testing is the most effective when no precedent exists for either product or process.[34]

Evaluation can be divided into two major categories, the evaluation of the effectiveness of the teacher, and of the student in attaining the objectives of the teaching. Falk and Dow lead one to conclude that a combination of methods of evaluation are necessary, such as (3.3).

> The use of criterion tests, provided these are valid and reliable;
>
> Assessment of the course by the students, using the same conditions;
>
> Records of interviews with and judgements of experts in the field concerning publications, contents of the course and so on;
>
> The consideration of all this information by a committee who are required to substantiate their opinions.

Putting into practise all the decisions made concerning the strategy, the experience gained from the field test and from the initial evaluation of that, is what comprises the implementation of the strategy (3.4). This entails planning the program of instruction, including actually assigning the personnel, media, facilities, and evaluation. It also includes the actual obtaining of the required media, facilities, personnel and students. Once again, since there may have been unforeseen changes between the time of selecting a strategy and its implementation, it is necessary to correlate and adjust these plans before actually conducting instruction.

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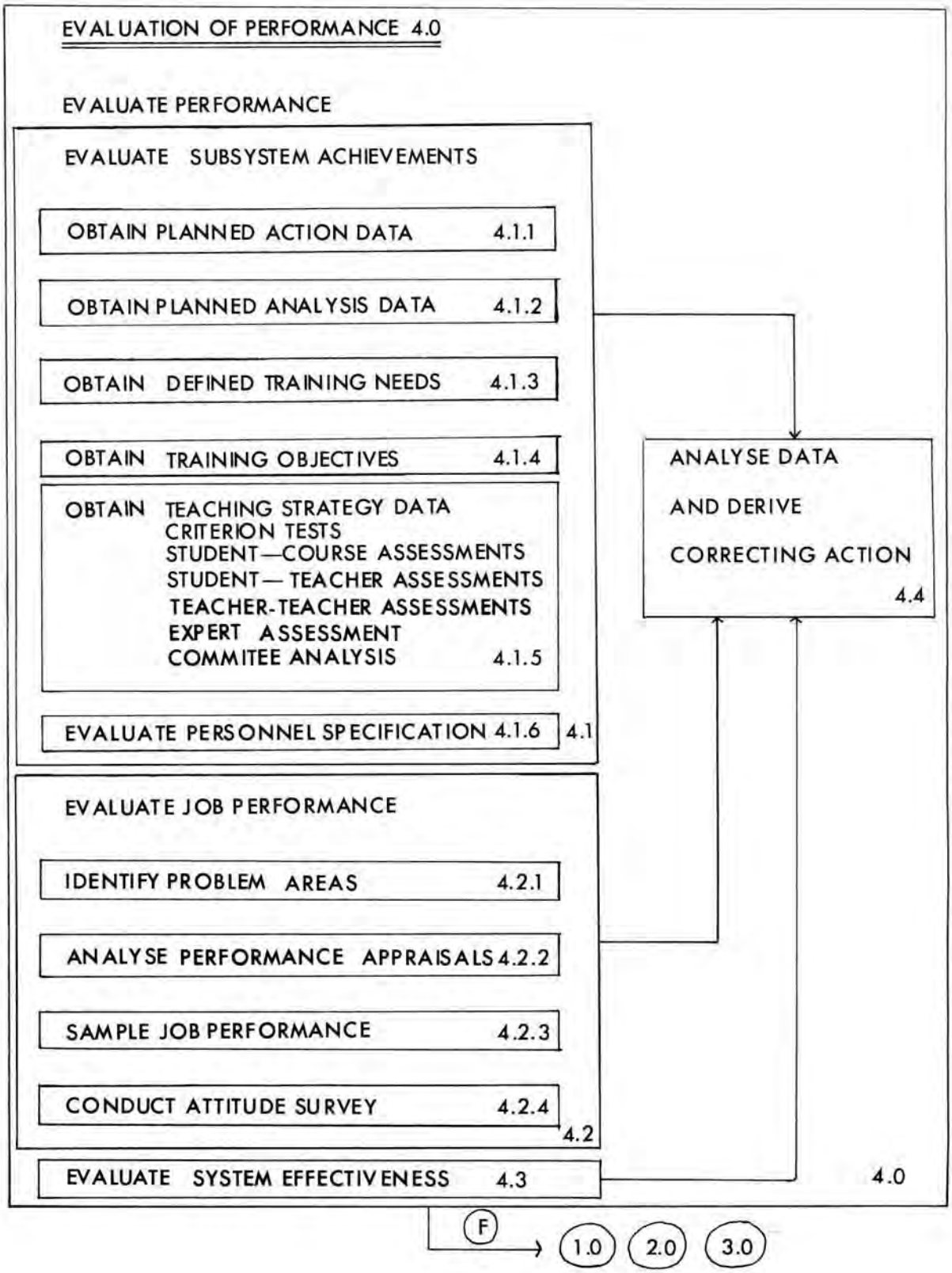
25. R.F. Mager and K.M. Beach: *op. cit.*, p 40.
26. W.R. Tracey: *op. cit.*, p 7.
27. I.K. Davies: *op. cit.*, p 28.
28. A.J. Romiszowski: *op. cit.*, p 37.
29. A. Nicholls and S.H. Nicholls: *Developing a curriculum*, p 57.
30. G.L. Gropper: *Instructional Strategies*, p 6.
31. W.R. Tracey: *op. cit.*, p 189.
32. I.K. Davies: *op. cit.*, p 29.
33. G.L. Gropper: *op. cit.*, p 5.
34. *Audio-visual Communication Review*, vol 4, 1956 (N. Rose and C. van Horn: Theory and application of pre-production testing) p 21 – 30.



A5 The Evaluation Subsystem

After instruction the evaluation measures are applied and adjustments made to the teaching strategy and instruction as before.

The evaluation sub-system (Fig 5)

From the descriptions of the previous sub-systems it should be evident that the process of evaluation is not one which is confined to the final stages of the model, as depicted originally. Evaluation is a continuous process which, for convenience, may be divided into formal, or that which requires formal action on the part of the teacher, and feedback, which may be regarded as more informal evaluation.

Evaluation of the following aspects has been provided for within other sub-systems:

The plan for the solution of the training and development portion of the manpower needs problem.

The job analysis needed to define the details of the training required.

The training needs identified.

The training objectives derived from the needs.

The training strategy developed to achieve the training objectives.

The students, the teacher, the contents of training and the evaluation system (4.1).

Examining the functions of which the model comprises, one can deduce that only one of these functions has to date not been evaluated. That one is the function *Derive Personnel Specifications*. However, since the aim of the model is to provide efficient personnel who are able to perform their jobs, and who find those jobs meaningful and socially integrating, logically, these three aspects should be evaluated as well. One should therefore identify problem areas, analyse the performance appraisals, take a sample of the job performance, and conduct an attitude survey (4.2).

Finally, in conformance with systems practice, the efficiency of the model itself should be evaluated, so that deviations from the objectives can be corrected (4.3).

The results of these forms of evaluation, as well as the previous forms of evaluation are fed back to the appropriate portions of the system and the required correcting action taken.

The Development of the Curriculum

The system model just described, was used as a vehicle for the solution of the problem of the development of the curriculum for the training of National Service instructors. As a first step the manpower needs were identified, and the assurance obtained that the manpower supply was sufficient to meet the needs.

In order to determine the exact nature of the job performed by National Service Instructors a job description was obtained of a representative sample of the population, using an existing job analysis system in use of the South African Defence Force *(Project Concord)*. It was found that some of the data collected were not applicable to this particular job, and this information was thus discarded. The job analysis revealed that the job of this particular instructor had been prescribed and circumscribed to a very large extent in order to reach peak efficiency in training as soon as possible, and make the best use of the necessarily limited experience of the National Service Instructors. On examining the completed job description it was found possible to eliminate certain of the tasks as not being within the scope of operations of the South African Defence Force College for Educational Technology. When the stage had been reached at which personnel specification needs to be derived, it was found that this was already the subject of a study by the Military Medical Institute, and that the results of this study could contribute to the feedback data needed in the study by the Military Medical Institute.

Using the data from the job description, as well as the knowledge and experience of trained instructors it was found possible to derive the training needs by examining the desired performance, existing performance, and deficiencies in performance and execution. Because of the nature of the training it was found necessary to derive a means of conducting the training formally rather than by on the job means.

The training needs provided the basis for the derivation of the training objectives. Terminal and enabling objectives were derived which conformed to the requirements expressed by Mager[36]. These objectives were then arranged in hierarchical order as a means of deriving the sequence in which they should be taught. This sequence was checked by means of a matrix,[37] and certain discrepancies found. These were rectified.

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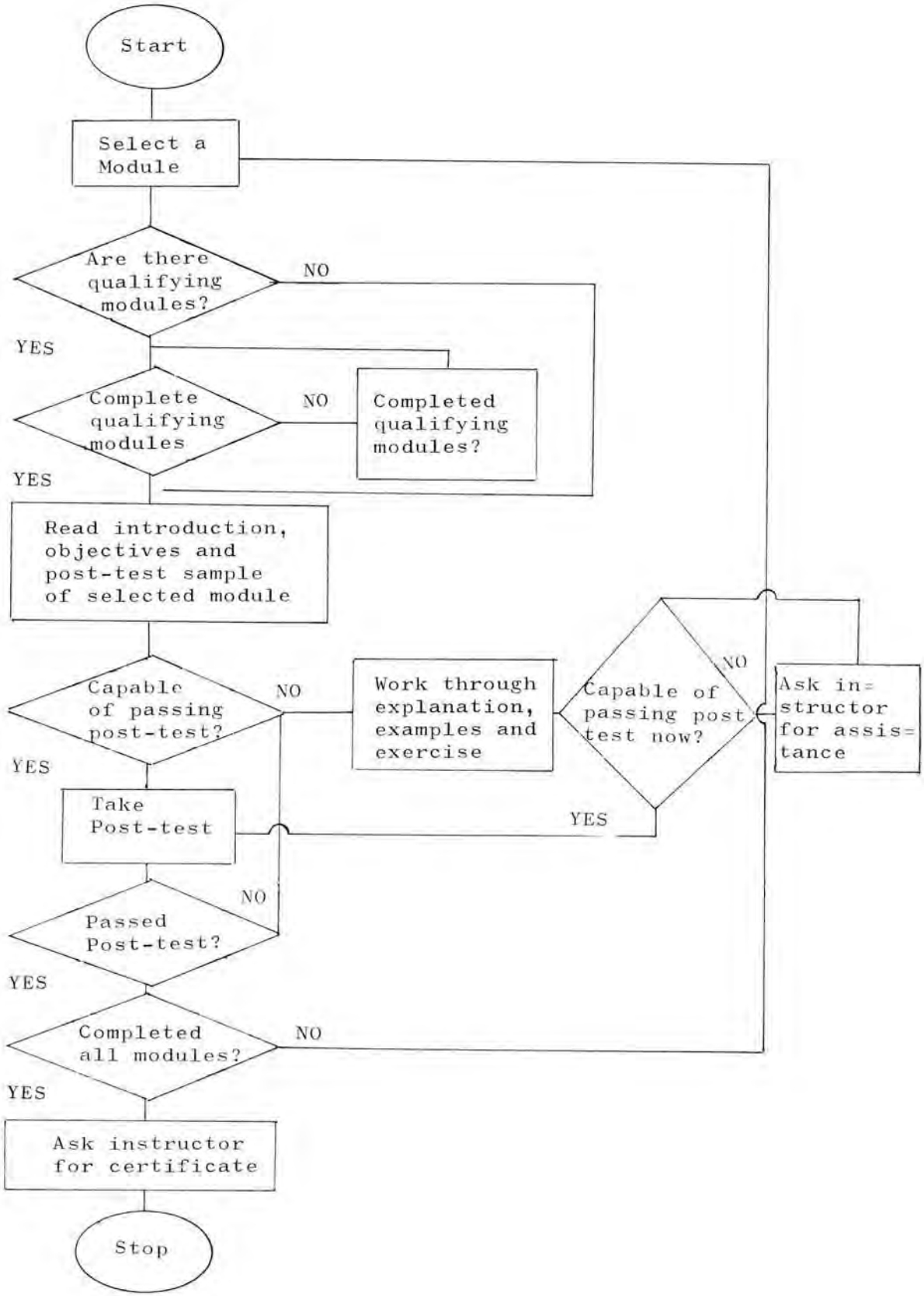
35. B. Falk and K. Dow: *Assessment of University teaching*, chapter 1.
36. C.A. Thomas (et al): *Programmed Learning in Perspective: A guide to program writing*.



A6 Diagrammatic Representation of individual Study Strategy.

It was found desirable to derive the criterion tests immediately after stating the objectives, so as to ensure that the achievement of the objectives was measured, and not merely that which had been taught. As a compromise between the demand for a 90/90 criterion[38] and the norm of 60% generally accepted in the Defence Force, a pass mark of 100% was required for each of the enabling objectives, and 60% for the terminal objectives. The latter was also influenced by the difficulty of defining objectively enough the characteristics of a good instructor. The factors considered when selecting a strategy of instruction were: the characteristics of the students; the facilities available and needed; the nature of the objectives; the availability and suitability of teaching and support personnel; media and methods; cost and time.

On examination it became evident that;

the facilities available were designed for large group instruction using conventional (primarily lecture) methods;

both cognitive and psycho-motor objectives had to be achieved, the latter requiring small groups for optimal practice by the students;

Skilled instructional personnel were in short supply;

a limited number of audio visual aids were available, and funds were not available for the acquisition of additional aids.

A second course, on behaviour modelling as a means of developing leadership skills, was to be conducted over the same period on the same students but by another organisation. This course was to be of three weeks duration and would make extensive use of an existing cable television system. Effectively, the instructor training course had to adopt a strategy which would permit the training of 750 students during each of two/three week period. The results obtained on this new course had to be at least as good as those obtained on the existing instructor training course.

The Selected Strategy

Having considered all the factors involved it became clear that there were two basic strategic options (or solutions) open: conventional instruction with the emphasis on large-group instruction; or individualised instruction.

The major advantage of large-group instruction is in its ability to cope with large numbers of students using a minimum of trained instructors. Its major disadvantage is the difficulty of obtaining student participation, and sufficient practice in the psychomotor skills without extensive use of audio-visual aids.

The major advantages of individualised instruction are its ability to cope with large numbers of students using a minimum of trained instructors, and allowing the instructors to act in the teacher-manager role, freeing them from the routine of instruction and allowing them to pay more attention to the problems of individual students[39]. The student is encouraged to proceed at his own rate and gains a great deal of active participation in the learning process. Its major disadvantage is also that it can become very expensive in its use of audio visual aids, unless properly controlled.

The decision was therefore taken to base the entire course on a strategy of individualised instruction using the written word as the main medium of instruction, making use wherever possible of ready-made training material, and adapting or producing that which could be obtained in no other way. Thus a multi-media individualised-instruction approach was adopted.

The Curriculum

For the purposes of this strategy each of the objectives derived was considered as a separate lesson and termed a module, interpreted as being an independent unit forming a part of the whole (Great Encyclopedia Dictionary). Each of these modules was developed as a separate entity having its own entry requirements, content, and post test.

Each module took basically the same form, essentially the form of a lesson as advocated by Staton[40] and implied in the works of Allen and Ryan[41] (1969) and Olivero[42] on microteaching. This form consists of:

An Introduction (or Set Induction), in order to generate interest in the planned lesson, to derive through the students the need for the achievement of the particular objective of the lesson, and to define clearly the title and objective of the lesson.

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38. I.K. Davies: *op. cit.*, p 210.
39. *Ibid.*, p 22; E. Stones: *An introduction to Educational Psychology*, p 387.
40. T.F. Staton: *How to instruct Successfully*, p 69.
41. D. Allen and K. Ryan: *Microteaching*.
42. J.L. Olivero: Micro-teaching: *Medium for improving instruction*.

The Objective, a statement of the objective of the lesson to clarify in the student's mind what he has to achieve by means of the particular module.

The Criterion test, actually a sample of the test that the student would be expected to pass on completion of the module.

Logical Development (or the body of the lesson), in which the explanations, examples, exercises, and questions are used together with appropriate audio visual aids to assist the student in achieving the objectives.

The Closure, containing a summary of the material dealt with in the module, and an attempt to stimulate the interest of the student in the next module.

The student was required to proceed at his own pace through the modules, following a certain preset sequence. Figure 6 shows the study stratety which an individual would follow.

Contents of Modules

A brief description of the contents of each module follows.

'B' series modules: Consisting of a single module, it contains an explanation of the course procedures, a chart showing the relationships between the various modules, a suggested sequence for studying the modules, and a control card wherby the student and the instructor can keep track of the student's progress.

'D' series modules: Consisting of two modules it contains the learning material for the objectives on objectives (the D in the title indicates its content (*Doelwitte*). Based upon the work of Mager[43] (1962) the first module defines the necessity for the use of objectives, the criteria of acceptability for objectives, and an exercise in which the student is expected to examine and if necessary correct 10 objectives. On completion he takes a criterion test in which he is required, under examination conditions, to examine and if necessary to correct 5 objectives.

In the second module the student is taken through a series of exercises in which he learns to analyse an objective into sub-objectives after the methods of Davies[44] and Mager and Beach[45]. For the criterion test he is required to select an objective from his own subject-matter area, secondly to start his preparation of a lesson which he may use in the achievement of the terminal objective of the course.

'H' or Hardware series: As the name implies the four modules in this series have to do with the use of audio visual aids in the teaching situation.

The first module deals with the use of the five senses in instruction, and the qualities required of the software specified. The software dealt with includes transparencies, polystyrene models, flash cards, and flip charts. The exercises and examples used are well illustrated.

The criterion test requires that the student define and describe the qualities of the software specified.

In the second module the student is required to make acceptable examples of the audio visual aids dealt with in the previous module, and to submit them for examination. In order to do this he is given the necessary materials and tools and examples of acceptable aids. He is encouraged to manufacture the aids that he will use in achieving the terminal objective.

The third module makes extensive use of two films *Visual Aids* in which a wide variety of audio-visual aids is demonstrated and instruction given in their use; and the film 'Don't just tell them' in which other visual aids receive the same treatment. The two films complement each other. During the viewing of the films the student is required to complete a workbook (or task book). The use of the task book was described in a previous study.[46]. The film is stopped at specified intervals or as the student requests, in order to enable him to complete the task book. The student may view the film as often as he feels necessary in order to complete the task book. The aspects which are not covered in the films are dealt with in the module itself. The criterion test is a criterion test is a written test concerning the aspects ealt with in the films and the module.

The fourth and final module in this series deals with the use of the various items of hardware (the audio-visual aids with which the software is used). The module consists of simple illustrated instructions for the setting-up, operating, and repair of minor defects in the equipment. The student is required to study these instructions in

43. R.F. Mager *op. cit.*
44. I.K. Davies: *op. cit.*, p 44.
45. R.F. Mager and K.M. Beach: *op. cit.*
46. R. Eberlein: *A Didactional Model for Job-oriented Training of Adult Workers*, p 89.
47. W.F. Hill. *Learning*, p 27.

conjunction with the actual items of hardware and practice the application of the instructions. The criterion test requires that he demonstrate unaided the setting-up, operating, and minor repair of each of the items of hardware.

'T' or theory series modules: The five modules in this series deal with the limited amount of theory that the student needs at this level. Covered here are the theory of learning, communication, instructor-student relationships, which the student is required to identify. In this video-tape additional factors related to the use of audio visual aids are included, by way of reinforcement of previous learning. The criterion test is a written one, dealing with the aspects of instructor-student relationships.

The fourth module covers the format of a lesson, and the preparation of a lesson-plan according to certain pre-set standards. As a criterion test the student is required to produce a lesson plan, in preparation for the completion of the terminal objective.

In a similar manner the fifth and last module in this series requires the student to develop a lesson plan for a demonstration lesson.

'V' or skills (vaardighede) series modules: The eight modules in this series deal with the component skills of teaching, using the micro-teaching approach. The material is based on the works of Perrot[49], Allen and Ryan[50], Olivero[51], and experience gained in the application of these approaches in the South African Navy and the Defence Force College for Educational Technology.

Seven video tape programmes were made of instructors modelling the correct use of the component skills, and the film *A Class of your own* was used to provide a model of the introduction (set induction) to a lesson. In each module he students are required to study the characterstics of the component skill, answer questions on the skill, and then develop and present their own version of that particular skill in a micro-lesson of about ten minutes duration. The presentation is recorded on video-tape by the student using a fixed television camera, and then replayed. During the replay the student is required, together with a small group of other students, to study the video-tape and assess the degree to which his performance matches that of the model. The group is then required to discuss the pros and cons of his performance objectively. On completion of this the student revises his micro-lesson and presents it again and again before his fellow-students until he and they are satisfied that he has reached the required standard. At this stage he again records his micro-lesson and views it. If he is satisfied he then takes the video-tape to his instructor, discusses the results with him, and then either moves on to the following module, or repeats the present module until he has reached a satisfactory level of proficiency. Once again the student is encouraged during this series to use it as an opportunity to develop the material and skills needed in achieving the terminal objective.

'F' or Facilities series modules: Based upon the work of Green[52] and Staton[53], as well as the Public Service Commission Handbook for Training Officials, this module deals with the preparation of a classroom and an instructional hut for use when teaching cognitive and psychomotor skills. Use is made of illustrations and exercises depicting the correct layout, as well as small models of classrooms. As part of the criterion test the student is required to arrange the furniture and audio-visual aids in a model of a classroom. The second part of the test requires that he repeat this test in an actual classroom using his own prepared lesson plan as the basis for his particular decisions.

'E' or Evaluation series modules: This, the last of the series, has four modules. Based on the writings of Ebel[54], Davies[55], Macintosh and Morrison[56], and the Bureau of Naval Personnel (NAVPERS), it covers the requirements for specified aspects of essay and objective tests. Included are the characteristics of an acceptable test (reliability, validity, efficiency and objectivity), the planning of a test, a need for model answers, and administering and scoring tests. The student is required to develop a suitable test for eva-

48. *Journal of Mathematics*, vol 1 and 2, 1962 (T.F. Gilbert: *op. cit.*)
49. E. Perrot: Microteaching in Higher Education. Research Development and Practice. Research into higher education monograph. Society of research into higher education. (University of Surrey, England, November 1977).
50. D. Allen and K. Ryan: *op. cit.*
51. J.L. Olivero: *op. cit.*
52. A.C. Green: *op. cit.*
53. T.F. Staton: *op. cit.*
54. R.L. Ebel: *Measuring Education Achievements*, (New Jersey, 1965).
55. I.K. Davies: *op. cit.*
56. H.G. Macintosh and R.B. Morrison: *Objective testing*

luating the performance of the students who attend his presentation which is part of the terminal objective.

> *The Terminal Objective:* As a grand finale the student is required to put together all the cognitive and psychomotor skills which he has learned during the course into at least two lessons of not less than twenty minutes duration during which he teaches a cognitive and a psychomotor skill.
>
> The student's performance is then assessed against a check-list covering the aspects generally accepted as being indicative of the 'good' instructor.

It is all too easy for the developers of a curriculum such as the one under discussion to assert that their curriculum is 'better' than another one. Unfortunately such an assertion is seldom substantiated by facts. An experiment was therefore designed to enable the effectiveness both of the curriculum, and of the systems model upon which the curriculum was based, to be tested.

The Null hypothesis formulated for this experiment is:

> there is no significant difference at the 5% level between the results obtained in a post-test by representative samples of randomly selected students trained in accordance with the curriculum for instructors developed by using the didactical model, and those trained in accordance with the curriculum develop by more conventional means.

The experiment (and the application of the model to the development of the curriculum) formed the basis of a Doctoral thesis submitted by the author to the University of South Africa[57].

The Testing of the Curriculum and the Model.

The implementation of the experiment, which was of the 'before and after Control Group type,' took place over a period of three weeks. Twenty-four National Servicemen of the Corps of Infantry of the South African Army who had been selected from the population by random methods were assigned to two groups of twelve students each. The two groups were assigned at random as experimental and control groups.

Instructors and facilities were similarly assigned at random to the control and experimental groups.

Both groups underwent a pre-test consisting of the criterion tests for the course. These objective-type tests (both written- and performance-type) were used to measure:

- Aspects of the theory of learning, instructor-student relationships, the form and content of the lesson and the demonstration lesson, and communication.
- Mastery of eight component skills of learning, based upon the micro-teaching approach.
- The preparation of a classroom and an instructional hut for use when teaching cognitive and psychomotor skills.
- The preparation of suitable tests for evaluating the performance of the students.
- Mastery of the selection and use of specified audio visual aids.
- The student-instructor's ability to apply the skills learned on course to the teaching of cognitive and psychomotor skills in at least two lessons of not less than twenty minutes duration.

The students in the experimental group were trained according to a curriculum developed by means of the model previously described, using a strategy of individualised study. The main medium of instruction was the written word, combined wherever possible with other media. Fourteen fully-trained instructors and ten assistant instructors were used to train approximately 1 488 National Service instructors among whom were the twelve of the experimental group.

The students in the control group were trained according to a curriculum developed by conventional means, and in use at the South African Defence Force College for Educational Technology up to that time. The strategy used was one of conventional instruction, that is instruction in a class by an instructor(s) using as the main medium of instruction the spoken word supported by selected audio visual aids. Two fully-trained instructors were used to train the twelve students in a course of three weeks duration.

The performance of the students was measured by means of the criterion tests used as post-tests. In the experimental group the criterion tests were taken by the students when they felt that they were ready for testing, on completion of each module of instruction. In the control group the criterion tests were taken on completion of the training course, as is the convention. Progress tests, similar to the criterion tests were taken on the completion of each

57. R Eberlein: *op. cit.*

relevant section of the course. The sections of the course correspond roughly to the modules of the experimental course.

The scores of both groups were analysed, using non-parametic statistics, to determine whether the application of the principle of randomisation has been successful, whether the treatments had benefitted the groups, and whether there was a statistically significant difference in the post-test results of the two groups.

The Results of the Experiment

The available data were divided into two sets, an Equivalent pre-test and post-test and a Full pre-test and post-test, as a result of the non-completion of certain aspects of the pre-test by the Control group.

In order to reduce the effects of uncontrolled variables on the results obtained by the two groups, the principle of randomisation was applied. To test the effectiveness of its application, a *Mann-Whitney U* test was applied to the pre-test data. It was accepted that obtaining a value of U greater than that shown in a table of critical values of U for two groups of 12 each, would not lead to the rejection of $H_2 : C_{pre} = E_{pre}$, thus proving the successful application of the principle of randomization. Furthermore the non-rejection of this hypothesis would indicate that a significant difference in the post-test results could only have been caused by the difference in treatments applied.

In the event, the value of U obtained from the analysis of the Full pre-test scores caused the hypothesis $H_2 : C_{pre} = E_{pre}$ to be rejected. However since:

the difference in pre-test scores can be attributed to the non-completion of the pre-tests by the control group; and

the analysis of the Equivalent pre-test scores did *not* cause rejection of the hypothesis, at the ,001 level,

it is concluded that the two groups are equivalent.

The application of the *Mann-Whitney U* test to both the Equivalent and Full post-test scores caused the rejection of the hypothesis.

$H_1 : C_{post} = E_{post}$, at the ,001 level.

From this it was concluded that:

The application of the model to the development of a curriculum for National Service Men Instructors produces a curriculum which is more effective than the produced by more conventional means.

In lay terms, the system model worked. But what of the instructor course? All-in-all 1290 instructors were trained over a period of six weeks using the new curriculum of these 1276 or -98,9% passed. Using as a basis for comparison the 24 students selected at random, and divided into control and experimental groups:

The control group (Old Curriculum) took 105 hours for the course and scored an average of 69,1% with 91,7% passing the course.

The Experimental group (New Curriculum) took an average 25 hours for the course and scores an average of 93,3%.

The challenge had been met and mastered!

Summary

In this paper an attempt has been made to sketch the problems facing instructors and those in charge of training, in attempting to control and use to the optimum the complexity and the promise of educational technology.

Using as an example the problem faced by the South African Defence College for Educational Technology, a systems model was applied to plan, prepare and implement a course for training 1 290 instructors of the School of Infantry.

The stages of development of the course, as well as its content, and an experiment to test the model and the course were described. It was concluded both that the model could be used to develop an effective curriculum, and that the particular curriculum developed enabled the instructors to be trained effectively.

The Future

Obviously, in tackling a task of this sort, the first of its type in the South African Defence Force, and possibly in the Republic a number of mistakes were made and a lot of lessons learned, especially in the practical handling of the large numbers of students involved.

Essentially though, the Defence Force now has a proven model which can be used for the development of training courses, and which holds the pro-

mise of enabling us in the future, to improve the efficiency and effectiveness of training not only of instructors but also of other groups.

'Breakthrough' is perhaps too strong a word for what the South African Defence Force College for Educational Technology has achieved but increasing the number trained per annum from 200 to 1 800 with a commensurate reduction in costs, without sacrificing quality must come quite close to that.

* * *

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