THE SYSTEMS APPROACH TO TRAINING AND EDUCATION

A Thesis Written in Partial Fulfilment of
The Requirements for the Degree of
Master of Arts

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

Figure		Page

Figure		Page

INTRODUCTION

In 1939 Vice Admiral K. G. B. Dewar, C.B.E. of the Royal Navy made the following observations about the nature of some of the training he had received as a young naval officer:

> Though the average age of my class was about twenty-four, the methods of tuition were those of the secondary school rather than the university. Professor Carlton J. Lambert, a very able mathematician, saturated in theory, demonstrated on the blackboard a number of problems which we copied into our notebooks and afterwards crammed up for the examination.
>
> The following are typical questions which I have found in my examination papers:-
>
> 1. A uniform bar of length 3 feet and weight 4 lbs. can turn freely about one end, and the other end is attached to a solid sphere of weight 18 lbs. and diameter 5 inches, so that the middle line of the bar, if produced, would pass through the centre of the sphere. The system swings as a pendulum, find the period.
>
> 2. . . . .
>
> 3. A planet describes its orbit (axis major 2a, eccentricity e) in T years. Determine its position when its velocity is greatest and the value of the velocity in this position.
>
> 4. . . . .
>
> 5. . . . .
>
> 6. Give an account of the compounds of phosphorous and hydrogen.
>
> It is really an amazing thing that officers should be withdrawn from responsible duties at sea to waste their time on such futilities . . . . Mathematical calculations are used in the design of guns, but gunnery officers do not design guns, and even if they did the Greenwich course would not have helped them.

. . . .

> If hard work were any criterion, Whale Island would have been an extremely efficient establishment, but unfortunately the Staff never seems to have decided whether to train the long course as gunnery officers, gun manufacturers, ordnance artificers, gunners, gunners' mates or seaman gunners. The only thing we were not taught was good shooting.

. . . .

> I do not want to waste more time discussing the futility of this training. It suffices to say that I soon forgot all the rubbish I had so diligently crammed and I eventually learnt my job by actually doing it at sea.[1]

A more up-to-date but possibly no more relevant comment was recently made by English:

> The textbook has reduced student interests and abilities to one level. It has promoted mediocrity, apathy, and the continuance of generations of passive learners. The exercises, questions, drills, etc., centre primarily on convergent answer-giving behavior. Rarely are students challenged by textbooks to produce divergent, creative acts or perform analysis on the logic of ideas or organization of content. Research on cognition and the need to produce and accentuate differences have relegated the textbook to the era of the hornbook and the duncecap. It is a relic in the educational museum of obsolescence.[2]

In a response to English, Soghomonian states in part:

> The problem is that too many teachers lean too heavily upon the textbook. These teachers we must help, or do without. If public education is no more than the classroom teacher directing the inventorying of meaningless data for unmotivated students, better to keep the kids at home and mail them the text - their parents could do little worse, and millions of dollars could be saved in personnel and construction costs.[3]

B. F. Skinner comments:

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[1]K.G.B. Dewar, The Navy from Within (London: Victor Gollanz Ltd., 1939), pp. 58-62.

[2]Fenwick English, "The Textbook-Procrustean Bed of Learning," Phi Delta Kappan, XLVII (April, 1967), 394.

[3]Sam Soghomonian, "The Textbook - Tarnished Tool for Teachers," Phi Delta Kappan, Ibid., p. 395.

The most widely publicized efforts to improve education show an extraordinary neglect of method. Learning and teaching are not analyzed, and almost no effort is made to improve teaching as such. The aid which education is to receive usually means money, and the proposals for spending it follow a few, familiar lines. We should build more and better schools. We should recruit more and better teachers. We should search for better students and make sure that all competent students can go to school or college. We should multiply teacher-student contacts with films and television. We should design new curricula. All this can be done without looking at teaching itself. We need not ask how those better teachers are to teach those better students in those better schools, what kinds of contact are to be multiplied through mass media, or how new curricula are to be made effective.[4]

The commentaries cited above are but a few of the host of criticisms which have been levelled at educational and training systems over the years. In all such comments, the common factor seems to be the need for improvement, stated or implied. In recent years particularly, there have been equally as many writers who have suggested all sorts of solutions to the problems which beset the complex educational and training systems. If the conscientious educator and trainer is to react effectively to the need for change and is to make decisions with respect to the best methods of bringing about necessary changes, he cannot afford to go about it in a haphazard fashion. The capability of the educator and trainer to cope with the rapidly changing requirements of their respective designs is no longer just a function of their willingness to do it and their experience and background, but necessitates the adoption of a disciplined approach which will

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[4] B.F. Skinner, "Why Teachers Fail," Saturday Review, October 16, 1965, p. 80.

guide the formulation of decisions and provide for accurate assessment of the results of those decisions.

In an address given to the Institute of Radio Engineers, Dr. C.R. Carpenter of Pennsylvania State University points out that:

> Educational institutions seem to have largely escaped technical modernization. They remain islands of archaic traditionalism in a social sea of modern technology. Consider, if you will, the engineering professor teaching servo mechanisms in the manner of a medieval monk, except that he may use a chalkboard! Is it possible to construct a new conceptual model of teaching and learning? Can such a model be conceived objectively, operationally, and functionally, without being cluttered, encrusted, and impeded by the mysticism, ritualism, and irrationality of traditionalism?[5]

It is the contention of this thesis that the Systems Approach which human engineers have evolved to enable them to develop and monitor complex man-machine designs provides such a model which can satisfy the requirements of educators and trainers in the design and control of their equally complex instructional designs. The primary aim of this thesis is to provide evidence to support this contention.

The achievement of this aim requires that the Systems Approach be represented in terms of the ultimate goal of any instructional design - student learning. In view of this, Chapter I provides a brief review of the most prominent theories of human learning and a brief insight into a few

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[5]C.R. Carpenter, "Problems and Possibilities of Electronic Systems in Higher Education," paper read at the Institute of Radio Engineers cited by J.J. McPherson, "Lets Look at the Systems Concept of Educational Planning," (Washington: U.S. Department of Health, Education and Welfare, 1960), p. 3 (Mimeographed).

theoretical considerations which are not so prominent.

Historically, learning theory has not had the impact on classroom practice one might expect. However, in recent years, certain well documented advances in the application of theory to practice in the area of human learning have occurred in the form of Programmed Learning and related techniques. The second chapter traces the development of programmed learning in its most widely employed configurations and establishes the relationship between programmed learning and the evaluation of a systematic approach to the improvement of learning environments.

While programmed learning as an element in instructional design proved its ability to promote learning, the process of programme production was recognized as an approach to structuring instructional design as well. The interrelationship of the disciplines of the programming process with respect to instructional design and of the human engineering process with respect to the man-machine design are discussed in Chapter III and the concomitant evaluation of the Systems Approach is outlined. The nature of this Approach and the manner in which it is being employed in representative educational and training designs is established.

On the basis of the foregoing developments, the concluding chapter ventures to suggest the manner in which the processes inherent in the Systems Approach hold out considerable promise for the educator and trainer who recognize the necessity of their student achieving relevant goals and point out the apparent benefits to be gained by the adoption of a highly systematic approach to educational and training decision.

A selected annotated bibliography on the application of programmed learning in education and training, a description of four recent developments in the field of instructional programming and an example of the application of the Systems Approach in a military training environment are provided as supplementary material to this thesis in three appendices.

CHAPTER I

LEARNING THEORY AND PRACTICE - A PRELIMINARY EVALUATION

The selection of personnel to be trained is made on the basis of their demonstrated ability to meet certain prerequisites dictated by the jobs for which they have been chosen. Their repertoire of knowledge and mental and physical skills resulting from their previous experience and/or training, falls short of the specifications of the job. This establishes the rationale for the training program. The training environment is structured to provide for a variety of trainer-trainee interactions designed for the benefit of the trainees, so that they will be provided with maximum opportunity to meet the job requirements. Figure 1 represents diagrammatically such a training environment in its most rudimentary form. When the students have achieved the established standards within such an environment, they are ready for the job.

It seems obvious that within the training environment, two activity patterns are established-the trainer (teacher) activity and the trainee (student) activity. The natural assumption is that these two are so closely intermingled that it is difficult to assess the critical characteristics of each. A "successful" teacher interacting with "capable"

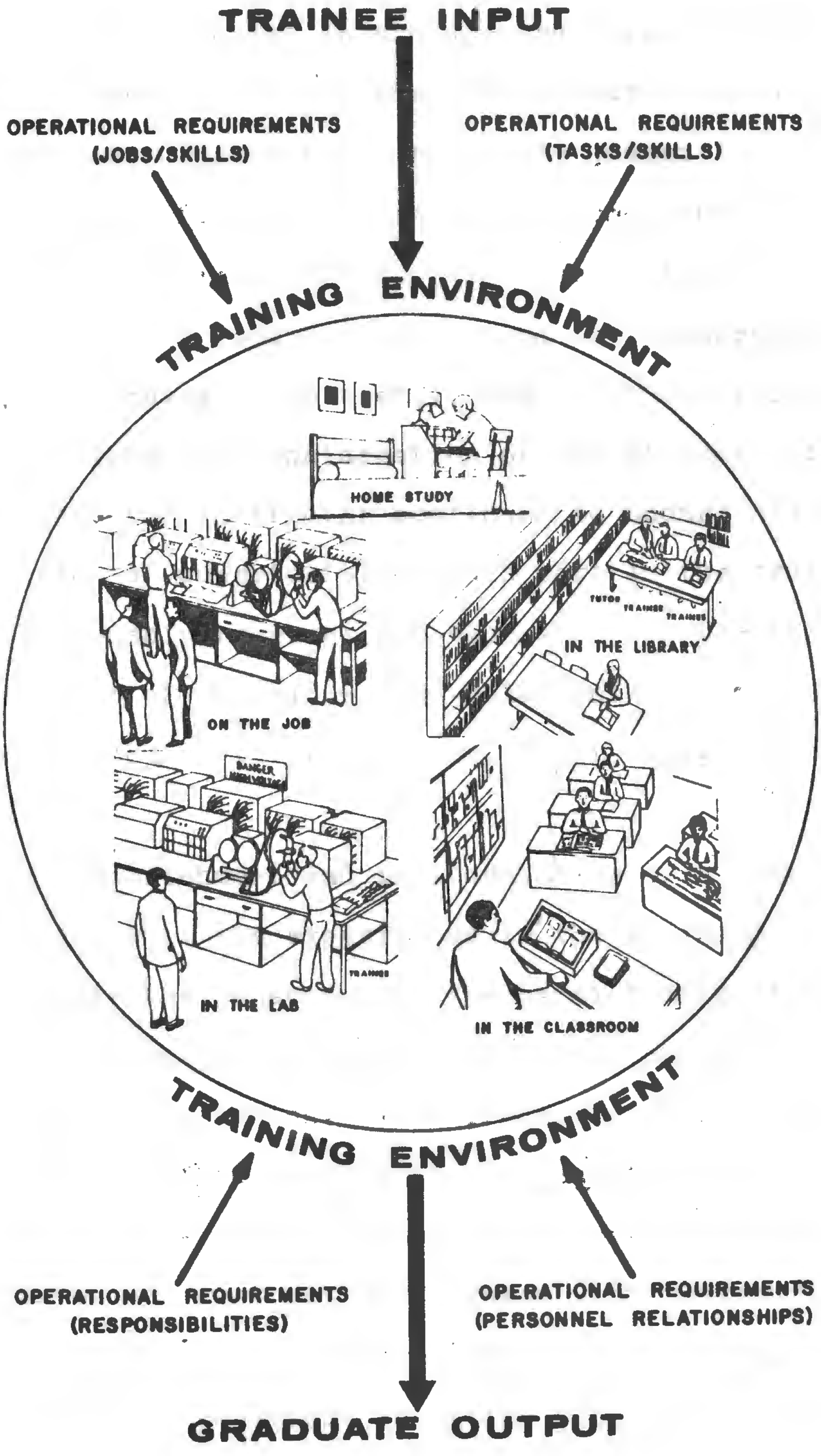

Fig. 1.--The training environment

students would be expected to produce graduates. However this is not always the result even when the prescription above has been established. Instructors are rarely judged in terms of student success or failure but rather by some other standards which often defy definition. Much has been written about the characteristics of a good instructor and the classroom techniques he should employ. Admittedly, some of these techniques have been developed in consideration of the student but it would seem that the instructor continues to occupy his traditional position of superiority and his part in the trainer-trainee relationship receives the emphasis. In the interest of re-assessment of this lop-sided relationship, it appears that a closer look at the trainee in the training environment is merited.

The establishment and implementation of a training program assumes that the experiences in the training environment will modify the behaviour of the participating trainees. Modification of trainees behaviour patterns then becomes the central process of training. This process of behavioural change has been defined by Hilgard[1] as learning with a caution that factors such as native tendencies, growth and fatigue do affect behavior but must not be confused with learning. MacCorquodale has defined learning as "...any relatively permanent change in behaviour resulting from past experience....Learning includes any behavioral change, not merely

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[1]Ernest R. Hilgard and Gordon H. Bower, Theories of Learning (3rd ed., New York: Appleton-Century-Crofts, Inc., 1966), p. 2.

those changes which are considered desirable or symptomatic of improvement."[2] Like Hilgard, he finds it necessary to warn about a number of specific factors which effect behavioral changes which do not qualify as learning. At the risk of riding rough-shod over the niceties of scientific terminology, this paper will consider that for all practical purposes, learning is a process which can be clearly identified only in terms of resultant changes in behavior (overt and covert). This provides an operational concept suitable for practical training purposes.

Having placed the learning process in a position of centrality in training, it is necessary that learning theory and learning research be investigated for the presence of constructs which may be useful to trainers as they make their plans to optimize trainee learning. Historically, this has always been a difficult process, for learning theorists are notoriously adept at hiding their intent from learning practitioners:

> The practitioner usually practices without the benefit of the theorist; the theorist theorizes and researches without adequate knowledge of the learning problems which the practitioner must solve.[3]

Skinner expresses it this way:

> It is true that the psychology of learning has so far not been very helpful in education. Its learning curves and its theories of learning have

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[2]Kenneth MacCorquodale, "Learning," Encyclopaedia Brittanica, XIII (1965), 859.

[3]William McGehee and Paul W. Thayer, Training in Business and Industry (New York: John Wiley and Sons, Inc., 1961), pp. 127-8.

not yielded greatly improved classroom practices.[4]

Further evidence of this unfortunate condition can be found in several issues of the Annual Review of Psychology. Stroud, for example bemoans the need for " . . . a guiding, testable, comprehensive learning theory."[5] Elmgren in a later issue, states:

> The need for a meaningful theory of learning that really influences the teacher in her work with children in school still persists and as a matter of fact very little has been done in comparison with the tremendous work on learning problems with rats in labrynths, guinea pigs and primates and so forth. Experimental psychologists in the United States, as elsewhere, have almost completely neglected the study of children's learning in the school situation.[6]

McGehee[7] suggests that this state of affairs has arisen for several reasons.

1. Experimentation required for theory development does not appear relevant to the practically-minded trainer. This has been particularly true with respect to research with the lower animals and even, in some instances, with children.

2. The necessity for exactness in research terminology has obscured the general principles of many theorists for all but the most ardent students of psychology.

3. The trainer has become confused to the point of

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[4]B.F. Skinner, "Why We Need Teaching Machines," _Harvard Educational Review_, XXXI (1961), 377.

[5]J.B. Stroud, "Educational Psychology," _Annual Review of Psychology_, II (1951), 282.

[6]John K.G. Elmgren, "Educational Psychology," _Annual Review of Psychology_, IV (1953), 381.

[7]McGehee and Thayer, _op. cit._, pp. 128-29.

despair by the dispute among theorists concerning the learning process.

In spite of these problems, further study of the contemporary learning theories is warranted on the basis that at least some of the principles and concepts contained therein which have withstood the ravages of time and criticism will provide a better basis for planning of military training than some of the folklore which has developed over the years. In an article on verbal learning, Underwood has supported this approach and suggests how one should proceed:

> To determine whether or not the laws of verbal learning are applicable to the classroom might seem to involve only a judicious consideration of the possibilities of scientific generalization. That is, one could assess the similarity of the condition between the laboratory and the classroom and then make judgements as to whether or not the principles found in the laboratory would hold in the classroom.
>
> The relationship between the laboratory and real-life situations can be evaluated in still another manner, and it is one which removes some of the dangers involved when the scientist over-extends his facts and theories. One may view the laboratory as a fast, efficient, convenient way of identifying the variables or factors which are likely to be important in real-life situations. Then if four or five factors are discovered to influence human learning markedly, and to influence it under a wide range of conditions, it would be reasonable to suspect that the factors would also be important in the classroom. But one would not automatically conclude such; rather, one would make field tests in the classroom situation to deny or confirm the inference concerning the general importance of these variables. These do not need to be extensive tests; they need only be a representative sampling of the range of variables. This procedure is likely to succeed because it deals only with phenomena of a magnitude large enough to have practical importance.[8]

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[8]Benton J. Underwood, "Verbal Learning in the Educative Processes," Harvard Educational Review, XXIX (1959), 107-117.

In the search for factors which would merit field testing in the training environment, a study of the various theories of learning must be carried out. To begin with, Hilgard has categorized them in the following manner:

> Learning theories fall into two major families; stimulus-response theories and cognitive theories, but not all theories belong to these two families.... The lines of cleavage between the two families of theories are not the only cleavages within learning theories; there are other specific issues upon which theories within one family may differ.[9]

Figure 2 illustrates the major differences and issues to which Hilgard refers with respect to the two principal families of learning theory in vogue at the time of his writing.[10]

Further investigation of these various theories within the two families causes some consternation on the part of the reader particularly as each theorist presents what seem to be lucid explanations and related experimentation for most of the critical learning phenomena. Of course, as Hilgard[11] points out, this is the very reason for the continued aura of legitimacy which these theories have enjoyed over the years. In order that some means of comparison could be established, Hilgard summarized each theory in terms of the way it handled certain problems of learning, namely learning capacity, practice, motivation, understanding, transfer, and forgetting.[12] An abbreviated representation of these summaries is provided

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[9]Hilgard, op. cit., p. 8. [10]Ibid., pp. 9-13.

[11]Ibid., p. 9. [12]Ibid., pp. 7-8.

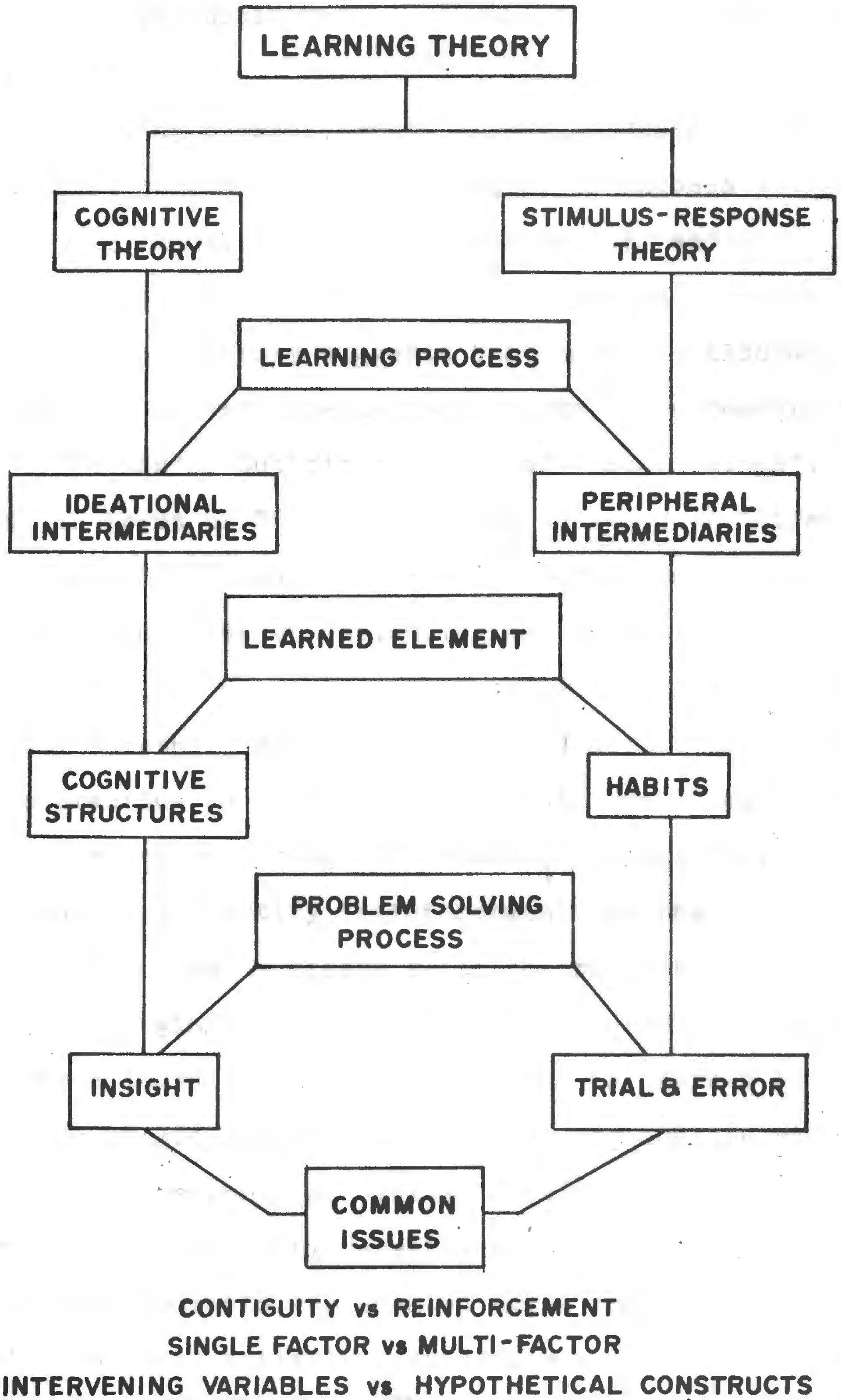

Fig. 2.--Issues on which learning theories divide

in Figure 3.[13] In consideration of this figure, the following points are noted.

1. Learning capacity would appear to depend on intelligence which is represented by the degree of success attained in the human in functions such as transference, mediation, differentiation and discrimination. In addition to these functions, however, theory suggests that capacity also depends on past development and experience. Thorndike represents this in terms of "bonds"; Guthrie in terms of "associations"; the Gestaltist in terms of "fields"; Lewin in terms of "life-space structures"; Freud in terms of "repressions"; and the Functionalists in terms of "psychological conditions".

2. Practice is considered of value by all theorists but the need for something more than "blind" practice is stressed. It must be practice in which factors other than stimulus and response alone are operating. Thorndike, Skinner, Hull and the Functionalists identify "reinforcement" as the prime additional factor, while others refer to practice with "meaning", "belonging" or "a difference". Guthrie indicates that the basic learning unit - the habit - is learned at full strength in a single repetition. Skills, are considered to be made up of an assembly of habits. The development of such habit groups takes place by repetition.

3. All theorists represented agree that the learner's "internal" desire to actively participate in the process is

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[13]Figure 3 summarizes the principal learning theories as outlined under typical problems in Hilgard's text <u>Theories of Learning</u> previously cited.

necessary to learning. The source of this desire does not appear to be clearly established by the theories being considered here. Thorndike, Guthrie, and Skinner consider that motivation is a function of reward or reinforcement. Hull and Tolman suggest that internal needs and the resultant drives give rise to motivated activity. Others indicate that learning goals and learning set affect the development of motivation. From these differing factors it is clear that motivation is a "personal" thing with the individual and that any external effects must be closely related to internal personal desires.

4. Handling of novel situations and solving of problems represents learning in which "understanding" is implied. All theorists deal with this "type" of learning but a very basic difference of approach is evident. The S-R theorist, taking a "molecular" approach to all learning, treats even the most complex behavior in terms of bonds, associations, or S-R pairs. These learned molecular units or groups are arranged by the individual through the processes of generalization and discrimination. This would seem to lead to the trial-and-error problem solving as indicated by Skinner. The more sophisticated explanation is that of "approximation" where the learner gets closer and closer to the solution as he varies the arrangement of his learned responses. The cognitive theorist take a "molar" approach and complex learning requirements are dealt with in terms of cognitive structure development and alteration. Tolman's "maps" and Lewin's "life-space" are examples of such structures. The develop-

ment of these structures and the changes which take place in the light of new learning situations are considered to result from sensible, reasonable adjustment and perception of relationships. These processes represent human "thinking" and "understanding" to the cognitive theorist.

5. Theorists are almost unanimous in their belief that similarity between old learned situations and the new to-be-learned situation holds the key to transfer. They differ, however in their definition of the nature of what must be common in the two situations. Theorists who tend to deal in molecular learned units accept Thorndike's "identical-element" concept with minor modifications. The cognitive theorists suggest that the commonality must exist in terms of molar structure indicating that transfer necessitates an understanding of essential relationships and common patterns rather than the existence of common elements of the patterns.

6. The S-R and the cognitive theorists consider that forgetting is in part, a function of time elapsed between the original learning process and retrieval. The S-R theorist emphasizes the weakening effect of disuse or lack of practice while the cognitive theorists emphasize the effect of interacting and interfering activities carried out by the individual during the period of disuse. (Retroactive inhibition). It is interesting to note that Freud considers that forgetting in the normal sense, doe not occur at all. For him, all forgetting is intentional (repression) and this seems like proactive inhibition as repression is usually considered to be the result of some previous "unsatisfactory" experience.

It is a temptation to consider the theories represented in Figure 3 as traditional for they are the ones most often described in general textbooks on learning. They also represent the two main points of view of those psychologists who, during the first half of the twentieth century, have sought to solve the puzzle of how learning takes place in the human being. They are also the base from which vast amounts of experimentation, evaluation, heated discussion and new approaches have evolved. In 1956 Estes described the situation this way.

> The field of learning represents a loose and shifting confederacy of research tradition with widely varying origin, viewpoints, aspirations and alliances with other disciplines.[14]

This state of affairs has made it extremely difficult for the trainer (or teacher) to make any headway in his search for factors which might be investigated in the practical learning environment. If one was to ask trainers and educators why they do not try to apply learning theory in their everyday practice the reply would more than likely appear in the form of a question: "If the psychologists - the specialists in human behavior - cannot agree among themselves, how can I be expected to risk application of any of the principles which they embrace?" This may be more of an excuse that a reason, but the result is virtually the same---little attention has been paid to developing theories since Thorndike's "laws of learning" were first enunciated. Although most

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[14]W. K. Estes, "Learning," Annual Review of Psychology, VII (1956), 33.

Schools of Education teach the learning theory which has developed since then, little of it seems to get into the classroom. The approach to classroom practice seems to have been one of pragmatism. If something has been found to work in the classroom in the past, it is used...and used...and used. This seemingly very practical approach to solving problems can be effective provided that the learning requirements were carefully determined in the first place and that they haven't altered since their initial definition-and therein lie the dangers of the pragmatic approach to many problems.

In the same review of 1956, Estes held out a ray of hope. He continued:

> The limited progress toward union or integration so far detectable is largely associated with the rather general acceptance of S-R reinforcement concepts as a descriptive framework for *elementary* learning phenomenon. Italics mine [15]

He further suggested that the earlier penchant of theorists to endeavour to develop all-embracing learning theories was being replaced by the emergence of " . . . numerous limited theories usually in relation to experimental programs and a replacement of verbal schemata by mathematical models."[16]

In the later chapters of Hilgard's text on learning theory, these trends are represented. For example, Functionalism while not new in time, does contain some of the essence of change suggested by Estes. The functionalist's tendence towards eclecticism, his lack of systematic theory and his willingness to embrace a comprehensive system until " . . . the facts are better ordered."[17], constitute a defin-

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[15]*Ibid*. [16]*Ibid*. [17]Hilgard, *op. cit*., p. 365.

ite move away from the conventional approach. The inclusion of the Functionalist's approach with the "traditional" in Figure 3 was done intentionally for comparison purposes. Hilgard extended his remarks with respect to the functionalist approach by predicting that contemporary theory would move in the direction of functionalism because ". . . it is an experimentalism, because it fits the American temper, it provides a kind of framework appropriate to much of American Psychology."[18] He further suggested that this movement was giving rise to an "operationism" and the development of functional models and miniature systems and he concluded on the following note:

> Contemporary psychology, to the extent that it is increasingly operational and increasingly concerned with mathematical models and miniature systems, reflects the general outlook that, in one form or another, has all along characterized the functionalist.[19]

At this point there is value in the examination of the work of theorists who have moved or are moving towards the functionalist point of view as well as those who have taken novel approaches to the nature and operating characteristics of the learning process.

For example, K.W. Spence, who from his early writings is recognizible as an S-R theorist,[20,21] admits in a recent

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[18]Ibid. [19]Ibid., p. 366.

[20]K.W. Spence, "The Differential Response in Animals to Stimuli Varying Within a Single Dimension," Psychological Review, XLIV (1937), 430-44.

[21]K.W. Spence and Ronald Lippett, "An Experimental Test of the Sign-Gestalt Theory of Trial-and-Error Learning," Journal of Experimental Psychology, XXXVI (1946), 491-502.

article that his position is not as tenable as he would like it to be with regard to the need for substantiation of the cognitive nature of some learned behavior. He stated:

> " . . . the S-R psychologist does not usually talk very much about such things as perception, meaning knowledge, cognitive processes, etc. I suspect, however, that he deals with pretty much the same things that the cognitive theorists do under different terms."[22]

He then proceeds to use a perceptual approach to cognition implying that the differences between the two kinds of theory have been highly exaggerated. Further evidence of Spence's desire to see some integration of existing learning theories is found in a proposal in which he suggests that " . . . we must work up from fields in which the data are best qualified, and where the interrelationships of variables have been most thoroughly explored."[23] He goes on to state 6 main "Levels of Laws" from which to start in the development of integrated learning theory. These laws consider such cognitive domains as perception, thinking and reasoning.[24] While this does not represent a significant move towards unified learning theory, it does indicate the increasing pressure being applied to S-R theorists to consider the activities which go on between the "S" and the "R" in the S-R paradigm. Or, as has been stated even more recently:

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[22]K.W. Spence, "Cognitive Versus Stimulus-Response Theories of Learning," Controversial Issues in Learning, ed. Henry Goldstein *et al*. (New York: Appleton-Century-Crofts, (1965), p. 17.

[23]Hilgard, *op. cit*., p. 459.

[24]*Ibid*., p. 460. See Fig. 67.

> It is so reasonable to insert between the stimulus and the response a little wisdom. And there is no particular need to apologize for putting it there, because it was there before psychology arrived.[25]

A very convincing case for what should go between the stimulus and response is presented by O. Hobard Mowrer in his writings on the development of a "two factor" learning theory. In the first of two volumes recently published, he has stated his position in this way:

> The present volume is "behavioristic" in the sense of approaching the topic of learning in the tradition of Pavlov, Thornkike, Hull and other objectivists. But it deviates from or transcends their tradition in that it re-admits to consideration various problems which the behaviorists had removed: hence its qualification as neobehavioristic.[26]

While it is not possible to deal with the development of his theory in all of its detail, it is worthwhile to consider the process by which he demonstrates a clear relationship between the S-R and cognitive approaches to learning in terms of emotions. Figure 4 represents the stages in the development of his position[27] in which he indicates that the early approaches involved two theories endeavouring to allow for all learning; Pavlov's and Bekhterev's classical conditioning and Thorndike's habit formation by the Law of Effect. As a momentary aside, it should be noted that B. F. Skinner also speci-

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[25] G. A. Miller, E. Galanter and K. H. Pribram, Plans and the Structure of Behavior (New York: Holt, Rinehart and Winston, 1960), p. 3.

[26] O. Hobart Mowrer, Learning Theory and Behavior (New York: John Wiley and Sons, Inc., 1960), p. 7.

[27] Ibid., p. 213. Figure 4 is reproduced here with the author's permission.

HISTORICAL & LOGICAL ANTECEDENTS OF PRESENT VERSION OF TWO-FACTOR LEARNING THEORY

TWO—FACTOR LEARNING THEORY, ORIGINAL VERSION

Conditioning (Pavlov, Bekhterev)	Habit formation (Thorndike)
Positive and negative unconditioned stimuli	Reward and punishment
Stimulus substitution	Response substitution

HULL'S DRIVE—REDUCTION THEORY

A monistic theory of reinforcement purporting to explain both conditioning and habit formation. Did not deal adequately with avoidance behaviour (active and passive) or with secondary reinforcement.

TWO—FACTOR LEARNING THEORY, VERSION TWO

Sign learning (fear conditioning)	Solution learning (havit formation)
Autonomic nervous system and visceral and vascular tissue	Central nervous system and skeletal musculature.

Showed that avoidance behaviour, to be adequately explained, must involve both sign learning and solution learning. Theory did not, however deal adequately with secondary reinforcement (type-2) or with the concept of habit.

PRESENT VERSION OF TWO—FACTOR THEORY

Incremental reinforcement (punishment)		Decremental reinforcement (reward)	
Primary reinforcement		Primary reinforcement	
Secondary reinforcement		Secondary reinforcement	
Danger signal on (fear)	Safety signal off (disappointment)	Danger signal off (relief)	Safety signal on (hope)

Figure 4.

fied two types of conditioning in his early work;[28] the Pavlovian type (Type S) and a type resulting from the contingency of a reinforcing stimulus upon a response (Type R). From type R came Skinner's operant conditioning model which gave rise to the development of Programmed Learning to be dealt with in greater detail later in this paper.

Hull's attempt to bring the two original views together into one theory in terms of habit strength is considered inadequate by Mowrer because it fails to deal with avoidance behavior or the effects of secondary reinforcement. In its place, he proposes that certain emotions become classically conditioned and then operate as mediators in more complex behavior. Mowrer states it this way:

> . . . living organisms make two radically different kinds of reactions; overt behavioral instrumental responses and emotional or physiological (autonomically mediated) reactions. The whole objective or function of the former is to control what happens to prevent (avoid) undesirable happenings and to ensure, or at least encourage, desirable ones. In other words, behavioral responses must work, or they are no good....On the other hand, the psychology of the emotions is very different. They are not intentionally designed to control external events; they don't move us or other objects around in the same immediate sense that contractions and relaxations of the skeletal (voluntary) muscles do, and we don't expect them to be instrumental in the same way at all. They constitute our feelings and are clearly distinguishable from our actions, our working (workable, instrumental) responses.[29]

Figure 5(a) illustrates the insertion of the mediating step

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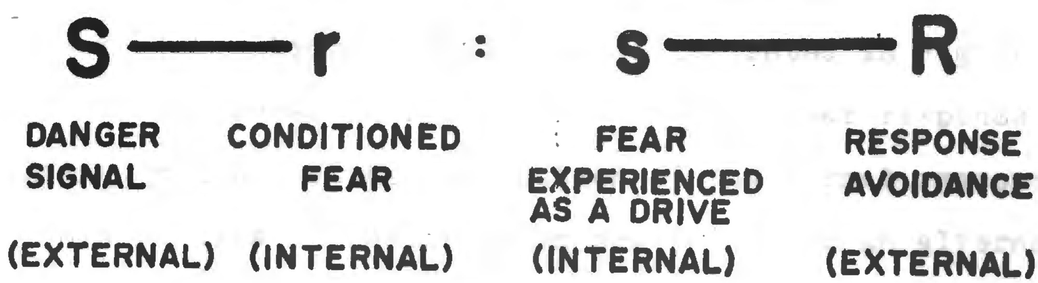
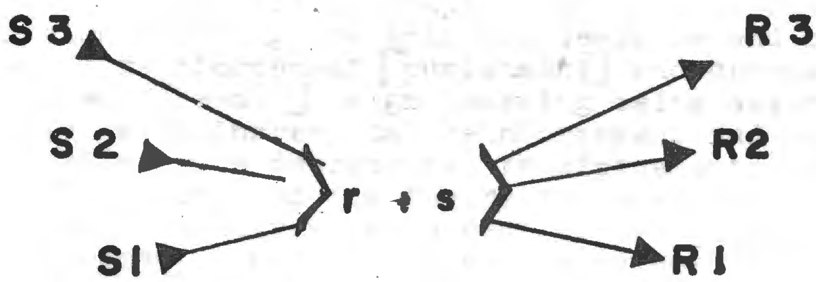
[28]B.F. Skinner, "Two Types of Conditioned Reflex: A Reply to Konorski and Miller," The Journal of General Psychology, XVI (1937), 242.

[29]Mowrer, op. cit., p. 61.



(a) MEDIATION BY FEAR



(b) CONDITIONING & TRIAL-AND-ERROR LEARNING PUT "END TO END".

Fig. 5v-Intermediary Processes

between the original stimulus and response, with the two factors, sign and solution learning, shown operating in sequence and interdependent rather than side-by-side and independent.[30] A further elaboration of this model illustrated in Figure 5(b) indicates the manner in which a conditioned fear response (r), resulting from S_1, causes inhibition of the normal response R_1. This results in the organism searching for an alternate response (R_2, R_3) which will satisfy without "punishing". S_2 and S_3 represent stimuli which also become related to the fear reaction so that, under the mediation of the fear, stimulus substitution and trial-and-error learning are explained.[31]

From this position Mowrer derives the final version of his theory illustrated in Figure 4, which he describes in this way:

> The second version of two-factor theory was "two-factored' in two different ways: it distinguished between sign learning and solution learning and between incremental reinforcement [punishment] and decremental reinforcement [reward], sign learning being associated presumably, with incremental reinforcement and solution learning with decremental reinforcement. Now the present version of the theory is two-factored in only one way: namely with respect to the <u>two types of reinforcement</u>, incremental and decremental. With respect to the other principle of classification employed in the second version the theory is now decidedly one-factored; that is, it assumes that all learning is sign learning and the solution learning (as well as response inhibition) is a derivative thereof.[32]

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[30] *Ibid.*, p. 77. Figure 5(a) has been developed to illustrate Mowrer's description of the nature of the intermediary process.

[31] *Ibid.*, p. 80. Figure 5(b) reproduced here with the author's permission.

[32] *Ibid.*, pp. 256-57.

While the detail given here may seem out of place in this paper, it falls far short of representing the true significance of Mowrer's attempt to show that learning does involve more than just the simplified series of S-R pairs triggered, one after another, until the final overt learned response occurs. While Mowrer uses fear as an example of a conditioned mediator, in the last version he expands the concept to include disappointment, relief and hope as other mediators. This well-documented position is not alone in considering the part that our emotions play in learning. Murray has also suggested that the emotions are integral operators in learning:

> Emotions are physiological and psychological responses that influence perception, learning and performance. The area of emotion is complicated by the lack of general agreement on a basic definition of the nature of the concept. For example, some people take the position that emotion is entirely different process from motivation. Others say that emotions are simply a class of motives. Some define emotion subjectively-in terms of the feelings experienced by the individual. Others see emotions as bodily changes. Most of these people have emphasized the reaction as the main component in emotion, but others concentrate on the perception of the situation that arouses the emotions or the effects of emotion on ordinary behavior.[33]

It can be seen that Mowrer's theory is a modification and continuation of certain facets of traditional learning theory. There have been in the past twenty-five years, however, a number of novel approaches to human learning. Possibly one of the most interesting of these has occurred as the result of research and development in the field of electrical/

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[33]Edward J. Murray, Motivation and Emotion (Englewood Cliffs, New Jersey: Prentice-Hall Inc., 1964), p. 49.

electronic automatic control equipment for the purpose of war. One of the leaders in this field in the early 1940's was Norbert Wiener who became interested in the development of computing machinery to solve gun-fire control problems and automatic tracking systems to point the weapons at the predicted point in space where projectile and target would meet. In the process of the evolution of such equipment, the most critical factor in automatic control was discovered to be feedback. Wiener describes the need for it in the following manner:

> . . . when we desire a motion to follow a given pattern, the difference between this pattern and the actually performed motion is used as a new input to cause the part regulated to move in such a way as to bring it closer to that given by the pattern.[34]

The functioning of this feedback can be illustrated by reference to Figure 6. The first example depicts the simplest non-automatic system which includes a human operator, who not only determines when the gun has reached the desired position, but provides the motive power which puts it there as well. The first indicator tells him where the gun should be pointed to achieve a hit. If the operator cannot determine visually the actual gun position at all times, he cannot position the gun accurately-he lacks essential information. However, a second indicator is provided (electrically or mechanically "attached" to the mounting) to provide accurately a feedback of the actual gun position. Any difference between the readings on the indicators represents the amount of

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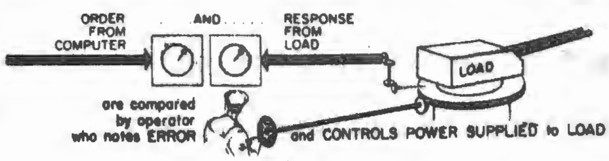
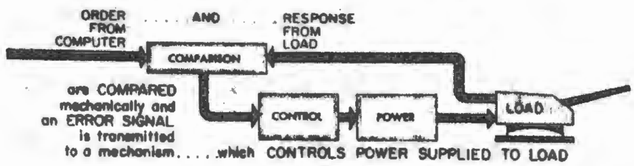
[34]Norbert Wiener, Cybernetics (New York: John Wiley and Sons, Inc., 1948), p. 13.

BASIC SERVO MECHANISMS

MANUALLY OPERATED SERVO SYSTEM



AUTOMATIC SYSTEM



COMPONENTS OF SERVOS

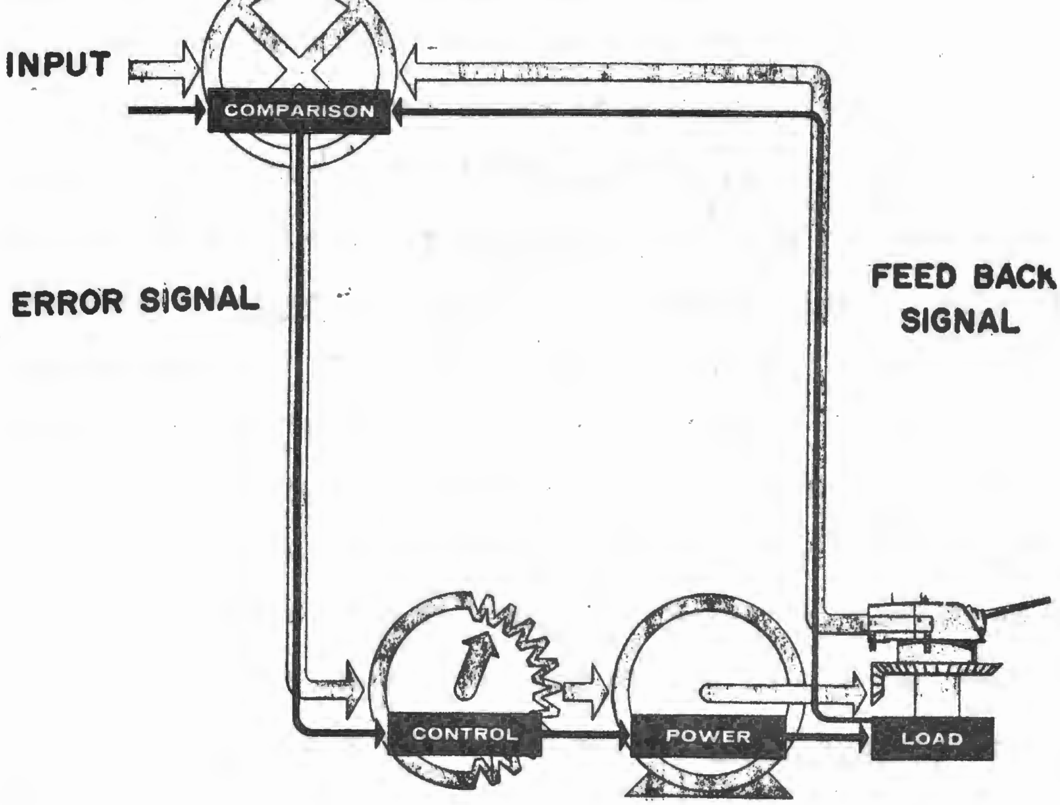


Figure 6.

aiming error at any chosen moment. The direction and size of the error indicates the action the operator must take with his handwheel to remove the error and ensure that the mounting is positioned in accordance with the desired pointing signal.

In the second case illustrated in Figure 6, the human has been replaced by a comparator, a controlling device and an electrical prime mover. In this system, the comparator continuously determines the error between the desired position and the actual present position. This error signal is communicated to the electronic controller. The controller assesses the nature of the error and develops a power signal directly related to the polarity and magnitude of the error signal which is passed to the prime mover. (Electric Motor). The prime mover drives the gun mounting in the direction which will tend to reduce the error at a speed proportional to the size of the error. The third section of figure 6 illustrates the system more clearly and identifies the two most important features--feedback and error. The error signal, which is derived from the difference between Input and Output, carries the "intelligence" which directs the system so that the gun mounting is automatically lined up to the desired aiming point. An actual gun mounting drive system would consist of two such systems; one to train the mounting, the other to elevate the guns thus providing aiming in the two required dimensions. Such systems are called servo systems or servomechanisms.

In developing such servo systems, Wiener was clearly interested in their human counterparts:

> . . . we should not avoid the discussion of the performance of certain functions. In some fire-control apparatus, it is true, the original impulse to point comes in directly by radar, but in the more usual case, there is a human . . . coupled into the fire-control system, and acting as an essential part of it.[35,36]

In a later volume, Wiener carried his interest in human functions and control considerably further. He states:

> When I communicate with another person, I impart a message to him, and when he communicates back with me he returns a related message which contains information primarily accessible to him and not to me. When I control the actions of another person, I communicate a message to him, [INPUT] and although this message is in the imperative mood, the technique of communication does not differ from that of a message of fact. Furthermore, if my control is to be effective I must take cognizance of any messages from him [FEEDBACK] which may indicate that the order is understood or misunderstood [ERROR] and has been obeyed.[37]

Wiener applied this concept to sociological aspects of human behavior and it would appear to have valuable carry-over into the structuring of the learning environment and trainer-trainee relationships which will be developed later in this paper. More important to learning theory development however, was his advancement of the premise that the <u>feedback mechanism</u> played a part in physiological and psychological human phenomena. While it is not possible to represent the fullness of his approach in brief excerpts, the following seems to sum up his intent:

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[35] Ibid.

[36] It must be recognized that later developments usurped most of the human functions and present-day equipment can and usually does track, predict, and aim the gun and fire the gun "untouched by human hands".

[37] Norbert Wiener, The Human Use of Human Beings (2d Ed.; New York: Doubleday and Co., Inc., 1954), p. 16.

> It is my thesis that the physical functioning of the living individual and the operation of some of the newer communication machines are precisely parallel in their analogous attempts to control entropy through feedback....external messages are not taken neat, but through the internal transforming process [Italics mine] of the apparatus, whether it be alive or dead. The information is then turned into a new form available for the further stages of performance.... In both of them, their performed action on the outer world, and not merely their intended action is reported back to the central regulatory apparatus.[38]

Wiener's work on cybernetics did not have much immediate effect on the existing theories of learning at the time. However it seems to have attained a degree of legitimacy along with communication theory and probability learning theory.[39]

It is obvious, even from a cursory glance, that most psychologists are unhappy with the explanations of the complex facets of human learning provided by the S-R and cognitive theories. The former approach seems too simple, while the latter appears too subjective. In recent years in the attempt to wrestle with difficulties, there have been a number of elaborations of Wiener's cybernetic approach. The "internal transforming process" previously cited seems to be in agreement with the strong belief in the mediatory nature of much of man's psychological activity during the learning process. Wiener's explanation of the development of conditioned reflex involving "affective tone"[40] and the manner in which it develops by feedback is strikingly similar to Mowrer's final version of his learning theory. Mowrer recog-

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[38] *Ibid.*, p. 26. [39] Hilgard, *op. cit.*, p. 375.

[40] Wiener, *Cybernetics*, pp. 150-52.

nizes this and states:

> The relevance of all this cybernetics to our present concern is clear. Self-regulation has previously been regarded as one of the most important yet mystifying characteristics of living organisms.[41]

The manner in which Wiener's approach is related more specifically to Mowrer's stand is expressed this way:

> . . . the first "effect" of a bit of behavior on the part of living organisms is to stimulate, to inform, to feed-back knowledge to the subject about the direction, extent, speed and general nature of the behavior itself. There then follows a second, subsequent effect in the success or failure of the behavior to satisfy the felt need or motive which originally prompted it. It is of course, this latter occurrence which Thorndike and other proponents of the Law of Effect have stressed-but stressed in such a way or in such a context, as to cause the first type of effect to be largely neglected.[42]

Mowrer considers in this context that his theory does have "room" for the cybernetic concept as a basis for adaptive behavior during the behavior rather than after it, and in this way accounts for the mediatory nature of most human learning processes.[43] He does not, however, clearly incorporate the feedback principle within the fabric of his theory. A more clearly defined representation of cybernetics in development of learning theory is found in the work of Miller et al where the problem of mediation is approached from the cognitive position.[44] The point of departure is found in the stated inadequacy of the S-R paradigm as a unit of behavioral

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[41] O. Hobart Mowrer, Learning and the Symbolic Processes (New York: John Wiley and Sons, Inc., 1960), p. 264.

[42] Ibid., p. 269. [43] Ibid.

[44] Miller, et al., op. cit., p. 9.

analysis:

> There is some reason to think that the reflex unit has been vastly overrated and that a good many psychologists would like to get out from under if they could. The reflex arc may have been very helpful in getting psychology started along scientific paths, but the suspicion has been growing in recent years that the reflex idea is too simple, too elementary.[45]

In their search for a more satisfactory behavioral unit, Miller _et al_. have derived a basic unit which evolves from the cybernetic principle of comparison (or test) between _what is_ and _what is desired_. Figure 7[46] illustrates the unit symbolically. An operational description of the unit is as follows:

> Obviously, the reflex is not the unit we should use as the element of behavior: the unit should be the feedback loop itself. If we think of the Test-Operate-Test-Exit unit-for convenience, we shall call it a Tote unit-as we do of the reflex arc, in purely anatomical terms, it may describe reflexes, but little else.[47]

The dissertation continues as the authors describe the means whereby the Tote unit can be generalized in terms of _energy_, _information_ and _control_. With reference to Figure 7, when energy is considered to be flowing from one place to another in the model, then the model represents the simplest reflex. When information flows, the model represents the level of abstraction represented by the S-R paradigm with some indication of what occurs between the "S" and "R".

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[45] _Ibid_., pp. 22-23.

[46] _Ibid_., p. 26. Figure 7 is reproduced here with the author's permission.

[47] _Ibid_., p. 27.

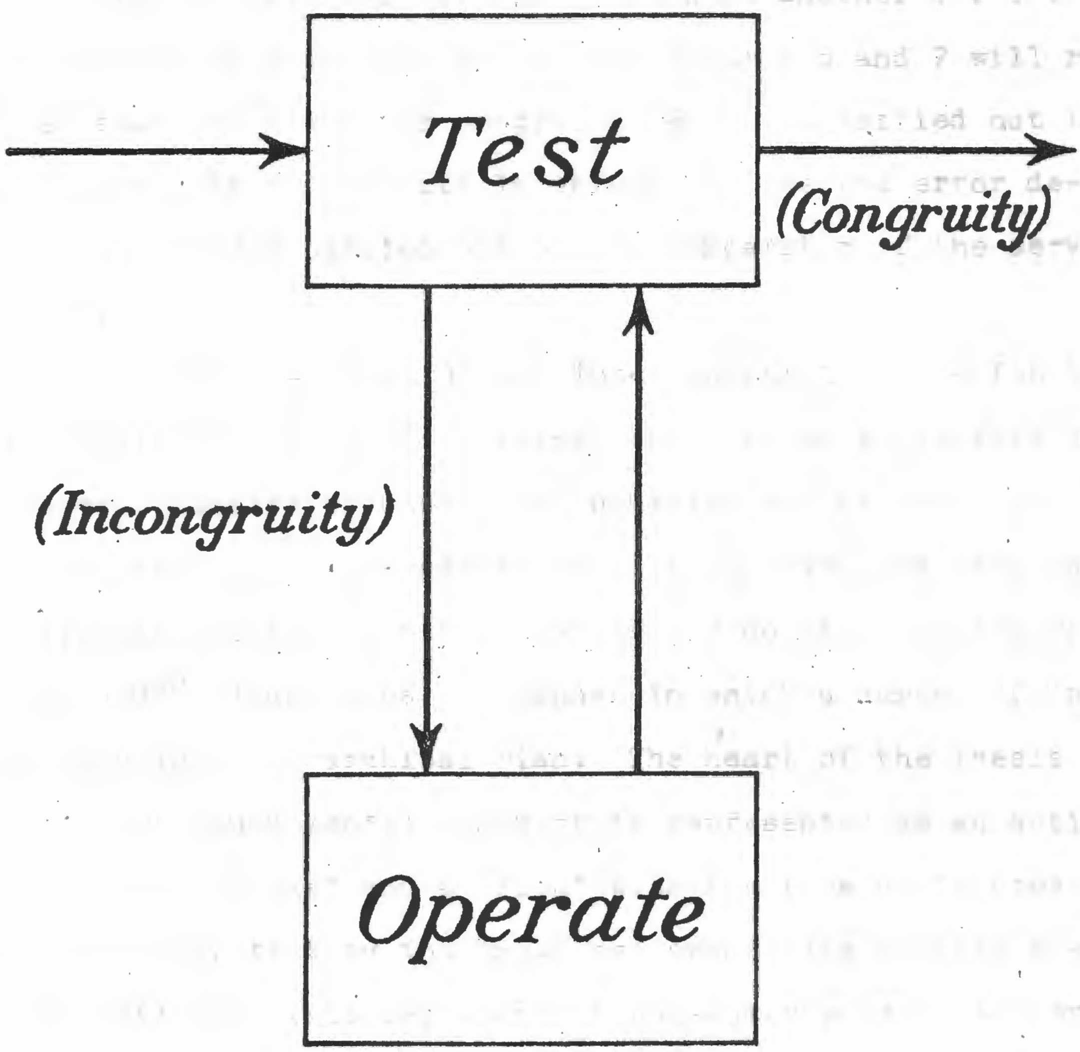

Fig. 7.--The TOTE unit

(Test for congruity). When "control" is implied by the arrows with direction indicated, the authors are dealing with a concept which " . . . appears most frequently in the discussion of computing machines, where the control of the machine's operation passes from one instruction to another . . .".[48] At this point a comparison between Figures 6 and 7 will reveal that the "test for congruity" which is carried out in the test unit of the Tote is very much like the error detection process carried out by the Comparator of the servo system.

In the weaving of the Tote concept into the fabric of a behavioral theory of learning, the authors illustrate how the most complex psychological behavior of the human being can be described more satisfactorily by using the Tote as a basic unit rather than the simpler S-R model. See Figure 8.[49] Figure 9[50] illustrates the manner in which a number of Totes operate in a hierarchical Plan. The heart of the thesis is that most human mental behavior is represented as an activity between an "Image" and a "Plan" with the tote units providing the means of testing the image and eventually putting the plan into action if this represents a necessary move to achieve overall "congruity".[51] Also the tote unit is viewed as the

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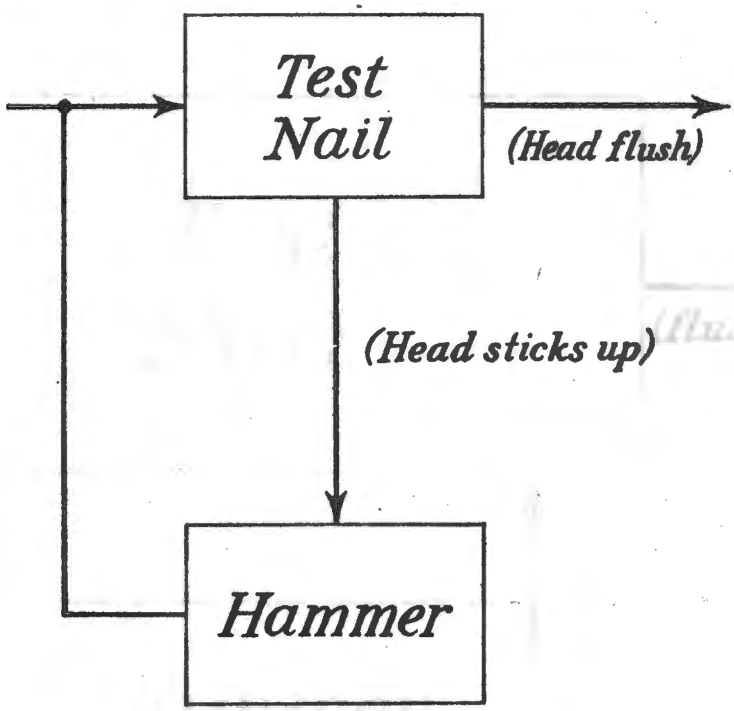
[48] Ibid., p. 28.

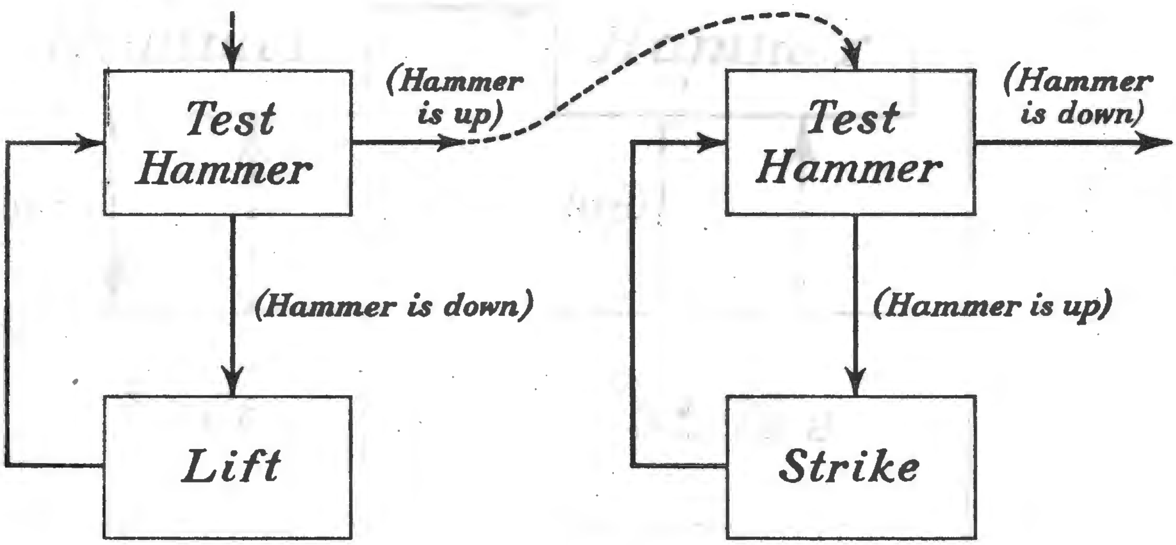
[49] Ibid., pp. 34-35. Figure 8 reproduced here with the author's permission.

[50] Ibid., p. 36. Figure 9 reproduced here with the author's permission.

[51] Ibid., p. 62.



(a) Hammering as a TOTE Unit



(b) Dashed line indicates how two simple TOTE units are connected to form the operational phase of the more complicated TOTE Unit in (a) above.

Fig. 8.--Operational use of TOTE units

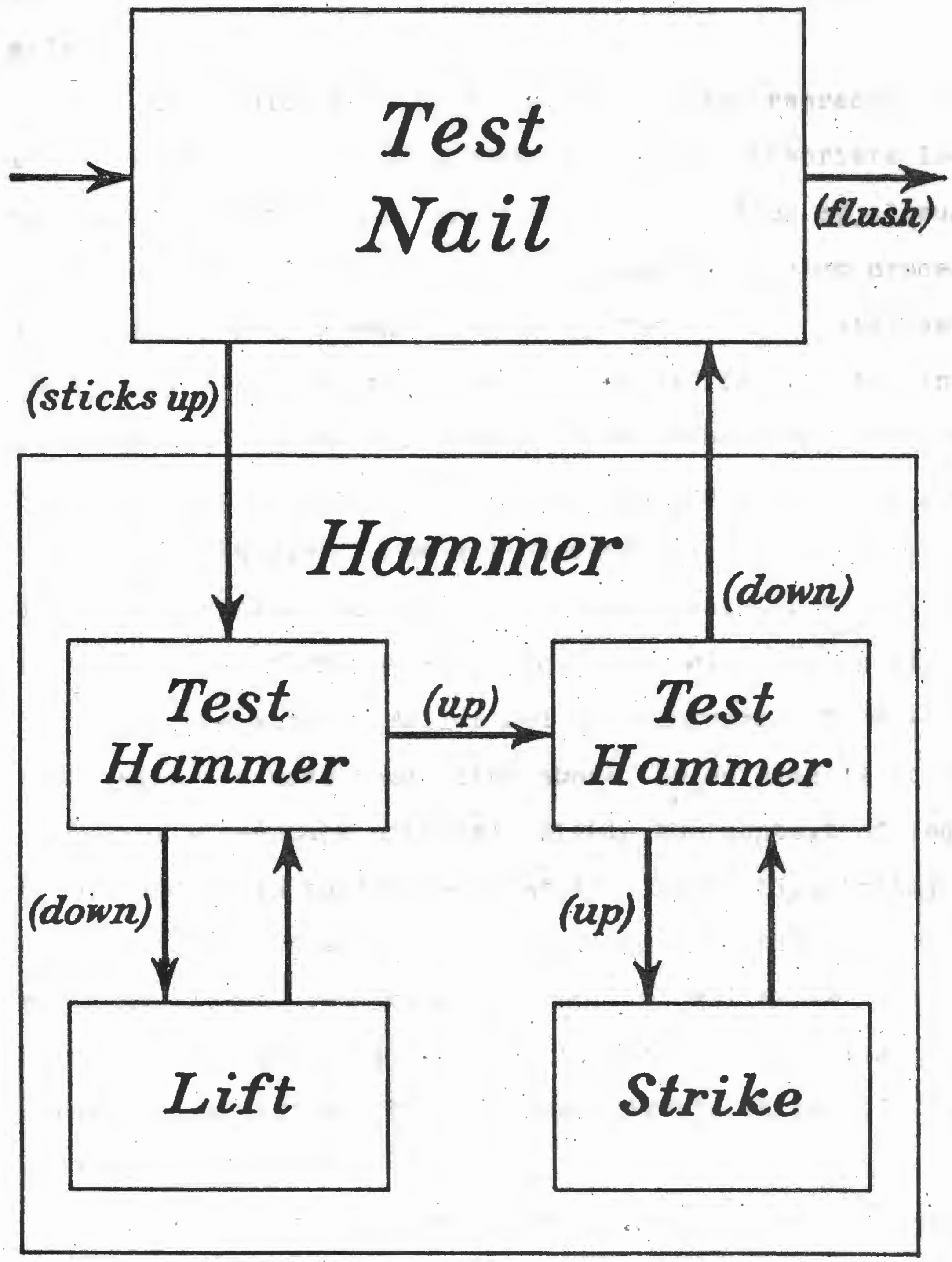


Fig. 9.--The hierarchical plan for hammering nails

control device which determines, by employment of feedback in the test phase, when a plan will move into the operational mode.[52]

In problem-solving situations, which represent some of the more complex human behavior, the S-R theorists lean heavily on the trial-and-error process. Miller et al, suggest that the tote model represents the problem-solving process more clearly and in many instances, the solution will depend upon " . . . whether the heart of the difficulty lies in the construction of a better Image or the elaboration of a better Plan.... For as Images become more accurate and more elaborate and more useful, we will become able to define more and more problems...to make them into something we can solve instead of something we must ignore or overpower or circumvent."[53] The work of Miller and his confréres, from which small excerpts have been cited above, is an example of the use of Wiener's feedback principle within the context of learning theory and it is considered that it clearly illustrates the viability of such a model in the field. In his most recent edition, Hilgard recognizes the work of Miller as a transformation of Gestalt psychology in which " . . . the good ideas are persistent, but not recognizable as gestalt psychology."[54]

To take the cybernetic approach one step further, a

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[52]Ibid., p. 63. [53]Ibid., p. 175.

[54]E.R. Hilgard and G.R. Bower, Theories of Learning (3d. ed.; New York: Appleton-Century-Crofts, 1966), p. 261.

recent book by Smith and Smith is of interest. The authors have based their extensive study of learning " . . . on an analysis of the sensory-feedback organization of behavior . . . a cybernetic approach, utilizing a term that implies self-regulation of activity."[55] The authors immediately take issue with the traditional S-R approach to learning in the following manner:

> Learning is more than the forming of new associations between stimuli and responses and the strengthening of existing associations. It is a process of re-organization of sensory-feedback patterning which shifts the learner's level of control over his own behavior in relation to the objects and events of the environment.[56]

This criticism is carried further in terms of the simplicity, the S-R reflex unit, and the attempt to use animal learning to predict all facets of human learned behavior following traditional theories. They suggest also that the cognitive theories have an outstanding weakness in that " . . . they have not defined their perceptions, cognitions, and organizational processes in objective terms and thus are not able to say how the perceptual or cognitive patterns influence subsequent behavior."[57]

As they develop their cybernetic model of human learning, the premise that the individual employs feedback control systems in learned behavior, is advanced as well as the position that the degree of control which the individual

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[55]K.V. Smith and M.F. Smith, Cybernetic Principles of Learning and Educational Design (Toronto: Holt, Rinehart and Winston, Inc., 1966), p. 2.

[56]Ibid. [57]Ibid., p. 37.

possesses develops as he advances in his ability to symbolize.

> In human evolution as well as in individual development, we see a progressive shift from direct control to symbolic control, which in time, permits a shift from primary spatial patterning of behavior to symbolic conceptualization of time, history and causation.[58]

Further to this, Smith and Smith suggest:

> Specialized changes which may be called learning occur in thinking or problem-solving. All of these changes as well as temporary changes, such as those due to motivational-emotional state, fatigue, adaption, and drugs can be analyzed in terms of changes in the patterning of feedback control.[59]

In this context, the authors develop their cybernetic approach to define the nature of human behavior in the areas of stimulus-response interaction, generation of response, spatial organization of response, delay, intermittency and extinction functions, motivation, and perception. All the elements of learning behavior as well as the various categories of learning are typified as reflecting differences in patterns of feedback control.[60] They summarize their approach in the following manner:

> Our basic hypotheses are that the behaving organism possesses the control properties of a cybernetic system but, as a living system, exhibits flexibility and changes in patterns of control. The basic properties of behaving cybernetic systems are:
> 1. they generate their own sensitizing and directionally oriented movements;
> 2. they detect differences between such self generated actions and certain targets or standards;
> 3. dynamic regulation and redirection is achieved by feedback control;

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[58] *Ibid.*, p. 79. [59] *Ibid.*, p. 210.

[60] *Ibid.*, pp. 211-20.

4. integration of receptor systems and of multi-directional components of response also is achieved by dynamic feedback control; and
5. control patterns are specialized in terms of temporal, spatial, kinetic, sampling, and transformational characteristics of sensory feedback.[61]

The approach cited above certainly seems more comprehensive in the manner in which it deals with human learning behavior, than many of the rudimentary traditional theories. The structure of the theory postulated here is strikingly similar to that proposed by Miller et al. in terms of the Image/Plan/Tote concept (previously cited) particularly in the manner in which both place the feedback (cybernetic) process in a central position and in the clear intent to ensure that both the simple as well as the complex learning behavior of man is dealt with on equal terms.

From the foregoing brief discussion of learning theory, it is evident that the way of the theorist has been difficult. Certainly no one theorist has been successful in convincing the world of training and educating practitioners at large that his particular approach will solve all their problems. However, in spite of the dissention and strife among theorists and their disciples, the spirited dialogue in succeeding journals between rival camps and the long-standing gulf between theory and practice, there are many who believe that learning theory has much to offer. In most cases the practitioner does not adhere to a particular theory from be-

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[61] Ibid., p. 354.

ginning to end but rather selects those elements which seem to receive attention in all theories. For example, Dunnette and Kirchner have selected such elements which they call "principles" of learning and have used them to assess the effectiveness of a variety of teaching methods. Active student participation, knowledge of results, reinforcement, practice and repetition are among the elements selected.[62] A glance back at Figure 3 of this chapter shows these to be elements of the majority of the theories represented. In a similar manner Silvern identifies "training factors" which he proposes must be considered in the development of a training environment.[63] Figure 10 presents these elements arranged to indicate the divisions of learning and psychological theory from which they have been derived.[64]

McGehee and Thayer, in relating learning theory and training practice, have selected certain aspects of learning theory and principle which they suggest:

> . . . seem particularly pertinent to industrial training including:
> 1. the nature of the learning process.
> 2. motivation and learning.
> 3. factors affecting learning efficiency
>   a. practice and conditions of practice
>   b. individual differences
>   c. nature of material to be learned.

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[62] Marvin D. Dunnette and Wayne K. Kirchner, _Psychology Applied to Industry_ (New York: Appleton-Century-Crofts, 1965), p. 74.

[63] Leonard C. Silvern, _Fundamentals of Teaching Machine and Programmed Learning Systems_ (Los Angeles: Education and Training Consultants, 1964), p. 19.

[64] Figure 10 is reproduced from Silvern's publication with the author's permission. _Ibid._, p. 19., Figure 6.

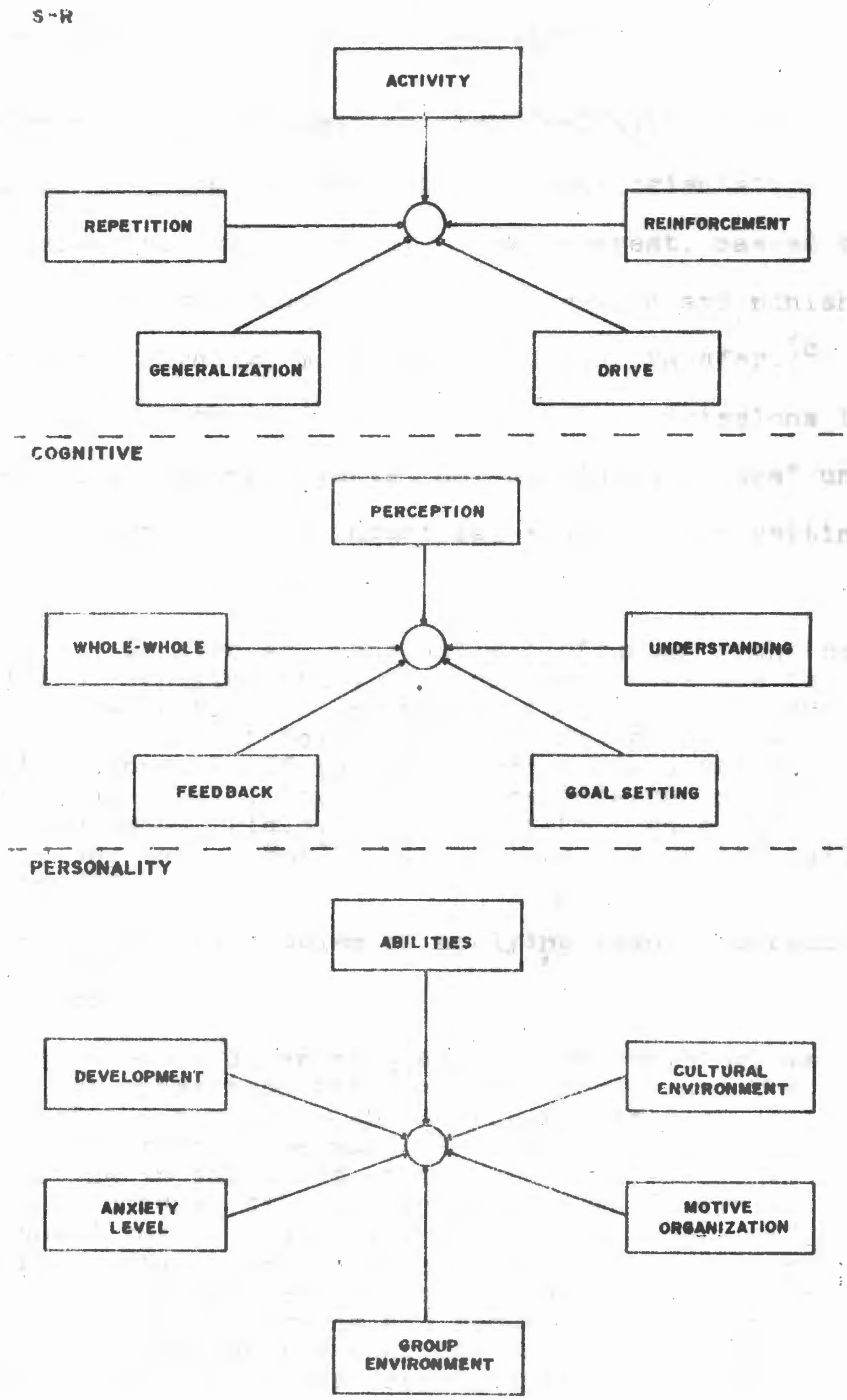

Fig. 10.--Training factors from learning theory

4. transfer of training and maintenance of behavior.[65]

In developing their proposition they deal with such specific elements as learning and performance, goal orientation, conflict of motives, reinforcement, task interest, massed vs spaced practice, knowledge of results, reward and punishment, whole vs part learning, meaningfulness and transfer.[66] The authors round out their discussion with the admissions that the principles must be regarded as "heuristic guides" until they are validated in the industrial and business setting.[67] They add:

> . . . we also are constantly confronted with the problem of applying them. [principles] If we are to train a new recruit to become a life insurance agent, what is the most efficient means of designing his training program? If we are to space his attempts to learn a sales talk, how long a time interval should we require between trials....We have to motivate the trainee to learn. How? What motives are specifically relevant?[68]

In dealing with this problem of applying theory to practice they conclude:

> In order to do an adequate job of training, we must first understand the learning process and the nature of the variables which affect learning. Once this is understood, we must re-examine the job and job-setting in the light of our new understanding. Unless we conduct this re-examination as "learning directors" rather than "trainers", we may very well fail to capitalize on inherent job characteristics which make learning easier; and we may overlook barriers which make learning and behavior maintenance inefficient; and we may continue to become enamored with each new gimmick or "revolutionary training

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[65]McGehee and Thayer, <u>op. cit</u>., p. 130.

[66]<u>Ibid</u>., pp. 132-78. [67]<u>Ibid</u>., p. 178.

[68]<u>Ibid</u>., p. 179.

device" as it comes on the market.[69]

In discussing the learner and his environment, Trow has also indicated some of the elements of learning theory which he considers relevant to the developing educational and training technology. The principles of stimulus-response with mediation, goal-seeking, memory, perception, reinforcement and feedback are specified as requirements for learning and necessary when developing the learning environment.[70] Figure 11 illustrates the interrelationship of these elements with respect to the dynamic learning organism.[71]

Holding, in his work on training principles, emphasizes the need to recognize certain learning factors which include knowledge of results, feedback, guidance, student activity (active response) part and whole learning, massed and spaced practice, and transfer of training.[72] After describing these factors and their relation to training in general, he indicates that problems of implementation do exist.

> What we have done so far is to consider the available research evidence bearing upon the problems of training. This is a reasonable procedure since it does give a solid basis for examining further the detailed problems of training particular skills, but it has two disadvantages. One of them is that things have been left out . . . while what has been said in previous

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[69] Ibid., pp. 182-83.

[70] William Clark Trow, Teacher and Technology-New Designs for Learning (New York: Meredith Publishing Company, 1963), pp. 18-33.

[71] Ibid., p. 34. Figure 11 is reproduced here with the author's permission.

[72] D.H. Holding, Principles of Training (New York: Pergamon Press, 1965), pp. 15-135.

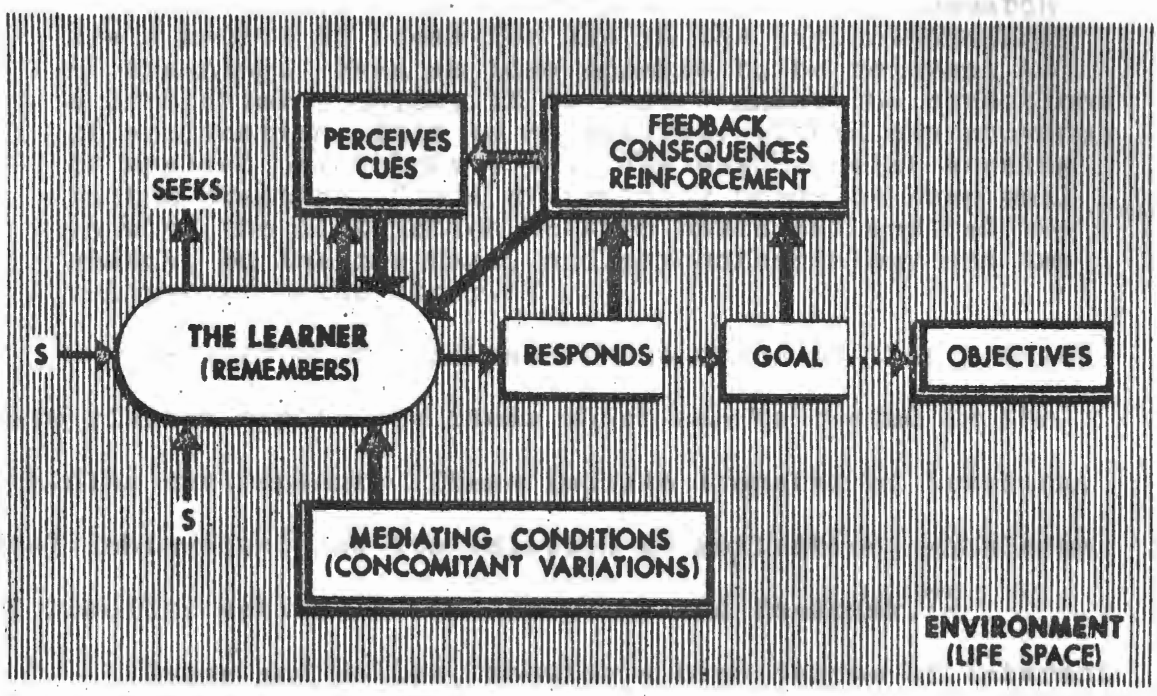

Fig. 11.--The organism learns

> chapters is the experimental truth it is certainly not the whole truth.
> The other disadvantage is the lack of simple definite recommendations to the trainer . . . Such rules as do emerge tend to be abstract and provisional, but yet can give some guidance towards better training.[73]

Crawford, in an article on training development and implementation, has also indicated the place of learning theory in training:

> The results from theoretical - learning research are a source of ideas for use in the psychotechnology of training. When an idea appears to be relevant to a particular problem, it is tested under the conditions of application; this is an activity within the province of applied psychology . . . The psychologist working in the practical field of training needs to keep well in mind the distinction between basic and applied research, on the one hand, and psychotechnology and development on the other.[74]

He goes on to indicate those areas of theory which have yielded applicable ideas which can be tested in the training environment. These include transfer of training, goal achievement and its relation to motivation, knowledge of results, active student response and feedback.[75]

Gagné and Bolles, showing a high degree of interest in transfer of training, have suggested that the measurement of learning efficiency must be in terms of successful transfer. They suggest that the conditions of learning can be considered under two headings, readiness factors and associative factors.

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[73] Ibid., p. 136.

[74] Meredith P. Crawford, "Concepts of Training," in Psychological Principles in System Development, ed. Robert M. Gagné (New York: Holt, Rinehart and Winston, 1963), p. 311.

[75] Ibid., p. 321.

The former includes motivation, reinforcement, set and attention while the latter includes mediation, intra-trial factors, massed and distributed practice and meaningful similarity of stimuli and responses.[76]

Indications from training experts who are seriously interested in providing the most efficient training and education for the most learners at the least cost, seem to stress that learning theory must be considered and <u>should</u> provide valuable assistance. However the problem which seems to appear in all situations is one of method. How can one be sure that a theoretical premise which "sounds good" or "makes sense" will actually prove useful? How does one implement such a premise within the framework of the actual learning environment? How can validation processes be established in the practical situation? What criteria should be used? It would appear that a <u>new approach</u> is necessary if the application of theoretically-oriented research results to the practical problems of human learning is to be realized.

The chapters of this thesis which follow will trace the development of such a new approach based on technological processes. Trow sets the stage for this development when he stated:

> . . . education is becoming less dependent ont folklore, tradition and heuristic procedures, and more on the methods of science as they have been developed chiefly by psychologists in the area of

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[76] R. M. Gagné and R.C. Bolles, "A Review of Factors in Learning Efficiency," <u>Automatic Teaching: The State of the Art</u>, ed. E. H. Galanter (New York: John Wiley and Sons, 1959), pp. 13-54.

> learning . . . The points of view of the scientist [theory] and of the technologist [practice] are likely to differ in one interesting respect: the scientist is impressed with what we don't know, and the technologist with what we do . . .[77]

It would seem that training and education must look to the technologist for a point of view which will provide a means for improving their situation and for the solution of their many problems. Further to this, Trow suggests:

> The true function of the technologist - whether industrial, consulting, military, or educational - is to employ psychology in a practical setting, that is to the problem of one or another of the arts, to translate general laws and principles into specific operations of machines and people.[78]

The particular technology to which trainers and educators should direct their attention has been variously termed "educational technology", "technology of training" and "behavioral technology". There seems to be little doubt that, whatever differences (real or imagined) there may be between education and training, the educator and the trainer are both interested in the establishment of environments within which the learner develops the desired behavioral patterns. While the patterns may differ to some extent, there seems to be no reason why the approach to common problems should not possess a high degree of similarity.

Glaser emphasizes the urgent need for an applied psychology and appeals to the psychologist and educator alike to assist in its development:

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[77]Trow, op. cit., p. 124.

[78]Ibid., pp. 124-25.

> Perhaps schools of education are too exclusively concerned with turning out teachers with a well-rounded view of the general problems of education and are not sufficiently concerned with practices in the application of knowledge from the modern science of learning. On the other hand, perhaps psychologists are too exclusively concerned with turning students of psychology into future Einsteins and into ultra-careful experimentalists, and need to temper this with the production of some Edisons and inventive applied scientists. At least let us try to apply effectively as much as we know; it might be enough to make a difference. The stimulus provided by the recent concern with "teaching machines" and "programmed learning" makes this result seem likely.[79]

Further concern for a mutually supporting science of learning and a technology of education has been expressed in an article by Melton. (Abstracted by Lumsdaine and Glaser). He indicated that there was a need for the development of some "explicit strategy" to hold together these two disciplines and concluded that:

> . . . the full realization of the human resources of this nation cannot be achieved without a science-based management of the learning process of our children.[80]

Several years after the pleas cited above, Mechner and Cook indicate that a technology to which the trainer and the educator can turn for guidance is available.

> The technology . . . is the outgrowth of behavioral science. While this technology is still comparatively young, certainly much younger than the science on which it is based, it is already successful and wide-ranging in its initial application . . . Manpower development systems, including training systems, educ-

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[79]Robert Glaser, "Christmas Past, Present and Future," Contemporary Psychology, V (1960), 28.

[80]A.W. Melton, "The Science of Learning and the Technology of Educational Methods, "abstracted by Lumsdaine and Glaser in The Causes of Behavior II - Readings in Child Development and Educational Psychology, ed. Rosenblithe and Allinsmith, (Boston: Allyn and Bacon Inc., 1966), p. 122.

> ational systems, and curricula depend for their successful design upon the current application of behavioral technology, with programmed learning serving as a versatile and powerful tool when it is correctly integrated into the total system.[81]

Another very convincing treatment of the relationship of theory to practice and the developing technology referred to above can be found in Hilgard's latest edition of Theories of Learning.[82]

Significantly, in the references cited and in many other similar summaries and treatments of behavioral technology, programmed learning seems to occupy a prominent place. This makes it necessary that programmed learning be carefully investigated if a clear picture of the state of behavioral technology is to be obtained. The chapter which follows describes the development of programmed learning and endeavours to clarify the place it occupies in the existing technology.

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[81]Francis Mechner and Donald A. Cook, "Behavioral Technology and Manpower Development, "Managing the Instructional Programming Effort, ed. Geary A. Rummler et al. (Ann Arbor: Bureau of Industrial Relations, University of Michigan, 1967), pp. 11-12.

[82]Hilgard and Bower, Theories of Learning, 3d. ed.; op. cit. Chapter 16, pp. 541-84.

CHAPTER II

PROGRAMMED LEARNING - PRODUCT OR PROCESS?

As implied in the previous chapter, programmed learning has made a very significant contribution in the field of human learning to-date. It is the purpose of this chapter to attempt to identify the critical elements of this contribution. The work of several pioneers in the field has had a profound effect on Programmed Learning as it is identified today so it is of value to describe their early efforts in some detail.

Sidney L. Pressey

Some writers have cited examples of "programmed" learning from as far back as Socrates but it is considered that the highly structured forms of today had their true beginning in the mid 1920's when Dr. Pressey of Ohio University first expressed publicly his dissatisfaction with the educational status quo. He was particularly perturbed over the amount of time the teacher spent in routine teaching and testing of rote materials. He summed up his feelings this way:

> The average teacher is woefully burdened by such routine of drill and information-fixing. It would seem highly desirable to lift from her shoulders as much as possible of this burden and make her freer for those inspirational and thought-stimulating activities which are presumably the real function of the teacher.[1]

In developing a device which tested, automatically scored, and actually taught children with a minimum of teacher participation, Pressey became one of the first educational technologists. His device is illustrated in figure 12 and a brief description of its operation follows.

The device had two modes of operation; the test-and-score mode and the teaching mode. In the first mode, a test on conventionally-taught subject matter consisting of multiple choice items was prepared and placed on the roller. (1) The student viewed each item in sequence through a window or slot. (2) The four keys on the right end of the device (3) provided the student with the means of indicating his selected answer. In this mode, when any one of the keys was depressed the roller moved to present the next question while a counter automatically recorded the number of correct selections made. An additional attachment (4) made it possible for the teacher to reward the student with a small candy or token when the number of correct answers, pre-set on a reward dial, had been reached. Upon completion, the mark achieved by the student was immediately available as a read-out on the counter.

In the teaching mode the student followed the same

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[1]Sidney L. Pressey, "A Simple Apparatus Which Gives Tests and Scores - and Teaches," School and Society, XXII (1926), 373.

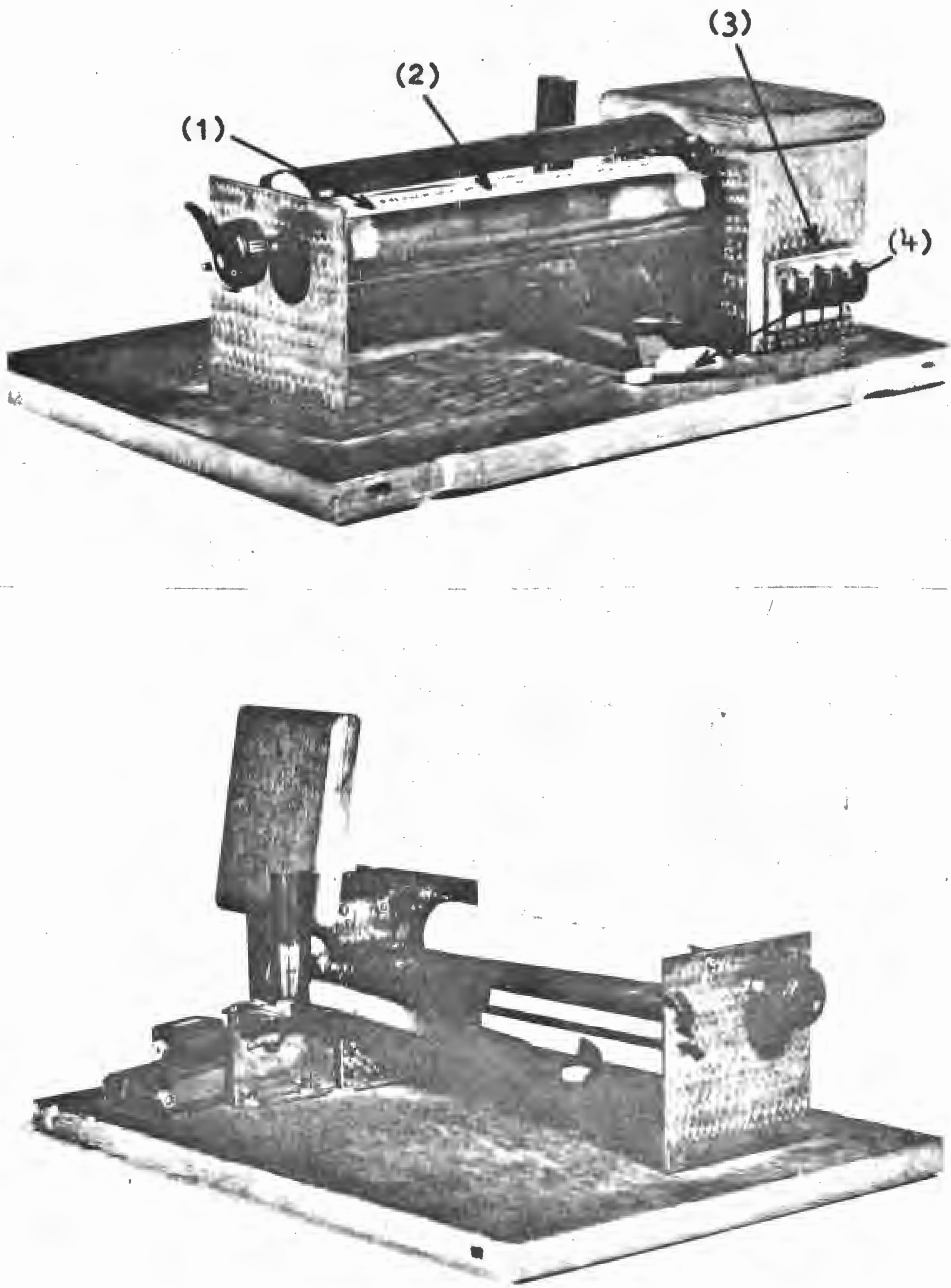

Fig. 12.--Pressey's Drum Tutor

procedure with one critical difference. The device was set so that the roller would advance to the next test item only when the correct answer key was depressed for the item at hand. The testing feature still operated with the counter providing a final score as well as a record of the number of "tries" made on each question.

Pressey summed up the value of the device in the teaching mode in the following manner:

> With this second set the device is exceptionally valuable for testing, since it is possible for the subject to make more than one mistake on a question - a feature which is so far as the writer knows, entirely unique and which appears decidely to increase the significance of the score . . . It tells the subject at once when he makes a mistake (there is no waiting several days until a corrected paper is returned before he knows where he is right and where he is wrong) . . . When he does give the right answer, the apparatus informs him immediately to that effect. If he runs the material through the little machine again it measures for him his progress in mastery of the topics dealt with. In short, the apparatus provides in very interesting ways for efficient learning.[2]

In a later report Pressey[3] demonstrated a further modification to the teaching mode which allowed the student to by-pass those items already correctly answered on two previous runs through the material. It was considered that this feature encouraged the student to keep on with the learning process as he viewed his progress in terms of the reducing number of items to be worked with on each successive run.

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[2] Ibid., p. 374.

[3] Sidney L. Pressey, "A Machine for Automatic Teaching of Drill Material," School and Society, XXV (1927), 549.

Pressey's work bore some fruit in several experiments carried out in the area of Thorndike's law of effect in general and the value of immediate knowledge of results in particular. The works of Peterson[4], Little[5], Angell and Troyer[6], and Angell[7] are representative. In 1950 Pressey came back on the scene to re-state his case using a simplified punchboard device which achieved results similar to those with the drum tutor described earlier. He concluded this report with the following suggestions:

> . . . "human engineering" can aid educational and training programs by test-teach devices of various types. The major purpose of this project has been to evidence the value of the basic idea, as illustrated by the punchboard, and to determine ways of using such a device in order to improve substantially instruction, or training.[8]

Stephens added that such devices (punchboard, drum-tutors etc.) may:

> . . . greatly expedite research regarding the

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[4]J. C. Peterson, "The Value of Guidance in Reading for Information," Transactions of the Kansas Academy of Science, XXXIV (1931), 291-96.

[5]James Kenneth Little, "Results of Use of Machines for Testing and for Drill upon Learning in Educational Psychology," Journal of Experimental Education, III (1934), 45-49.

[6]George W. Angell and Maurice E. Troyer, "A New Self-Scoring Test Device for Improving Instruction," School and Society, CXVII (January, 1948), 84-85.

[7]George W. Angell, "The Effect of Immediate Knowledge of Quiz Results and Final Examination Scores in Freshman Chemistry," Journal of Educational Research, XCII (1949), 391-394.

[8]Sidney L. Pressey, "Development and Appraisal of Devices Providing Immediate Automatic Scoring of Objective Tests and Concomitant Self-Instruction," Journal of Psychology, XXIX (1950), 447.

> learning process. Data such as that which Thorndike and his associates gathered laboriously by detailed individual procedures were quickly obtained from entire classes. It would appear that these devices were valuable research instruments. Also as a project in human engineering, the findings suggest ways of increasing efficiency in learning or training by special organization of practical tests or by facilitated retesting.[9]

The significant results of the work of Pressey and his associates can be summarized in the following form:

1) Mechanical and other devices were devised which did test, score and teach with minimum teacher participation.
2) Improvements in teaching practices were illustrated in a practical school environment.
3) Learning theory was implemented in a practical, well-controlled manner in the normal classroom environment (Thorndike's Law of Learning[10]).
4) The stage was set for further applied research in human learning.

In spite of these foundations, the hoped-for improvement in education and training urged by Pressey and his associates was not to be realized for many years. Silverman

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[9] A. L. Stephens, "Certain Special Factors Involved In the Law of Effect," in Teaching Machines and Programmed Learning, ed. A. A. Lumsdaine and R. Glaser, (Washington: National Education Association of the United States, 1960), pp. 92-93.

[10] Pressey, (1926), op. cit., p. 373., Reference to Thorndike's Laws of Learning as they relate to these devices is made in a footnote on this page.

seems to represent the general attitude of most writers in the field as they reflect on this failure when he states that it probably was due to:

> . . . the absence of systematic programming techniques and to the emphasis placed on testing rather than learning . . . . It would appear that Pressey was well ahead of his time, but neither science nor public opinion was able to encourage his efforts.[11]

Bhurrus F. Skinner

While the work of Pressey and his associates represented an important first step in the development of an instructional technology, it is recognized[12,13,14] that the real impact of this applied research did not materialize in any substantial way until the work of Dr. B. F. Skinner of Harvard University was made public in the mid 1950's. In one of his first articles on application of theory in a classroom setting, Skinner acknowledged the earlier work of Pressey and suggested that the approach was not accepted primarily because he had been working against a background of psychological theory which " . . . had not come to grips with the

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[11]Robert E. Silverman, Automated Teaching: A Review of Theory and Research, A Technical Report NAVTRADEVCE 507-2 (Port Washington, New York: U.S. Naval Training Device Centre, 1960), p. 1.

[12]Ibid., p. 2.

[13]Lawrence M. Stolurow, "Programmed Instruction and Teaching Machines," The New Media and Education, ed. P. H. Rossi and B. J. Biddle, (Chicago: Aldine Publishing Company, 1966), p. 125.

[14]Arthur A. Lumsdaine, "Teaching Machines" The New Media in Education, ed. Jack V. Edling, (Sacramento: Sacramento State College Foundation, 1960), p. 52.

learning process".[15] This attack on Thorndike's laws of learning, which Pressey claimed to be applying leads one to wonder what significant advances had been made by Skinner during the intervening years.

A detailed discussion of the reported work carried out by Skinner in over 30 years of research and development in the field of learning is neither practical nor necessary in this dissertation. However, (in the interest of an understanding of the contribution he has made to modern instructional technology,) it is of value to consider briefly three major phases in the development of his theoretical and technological position.

Phase One (1930-1936) - Orientation

During this initial period of his career, Skinner published twenty papers dealing primarily with his study of the reflex as a possible basic behavioral unit and the process of conditioning as a possible source of all learned behavior. In one of his earliest papers[16] the pattern is established as he traced the historical development of the reflex concept from which he inferred that there was only one characteristic by which the concept could be defined and that was by " . . . the observed [Italics mine] correlation

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[15] B. F. Skinner, "Teaching Machines," Science, CXXVIII (1958), 969.

[16] B. F. Skinner, "The Concept of the Reflex in the Description of Behavior", Journal of General Psychology, V (1931), 427-458.

of two events, a stimulus and a response".[17] While this is not very profound, it is significant that Skinner stripped away many embellishments which had been attached to the concept by previous writers. He considered that the extensive efforts of theorists to account for assumed events between the stimulus and the response in psychical and physiological terms were incidental having resulted from "unscientific presuppositions".[18] He concluded this paper with the consideration that the principle of the reflex was germane to the description of behavior.

Having established for his own purpose the relevancy of the reflex to the analysis of behavior, he proceeded to extend the concept to the behavior of the organism as a whole. At this point he found it necessary to clarify the nature of the stimulus and response - the basic elements of the reflex. One of the most serious difficulties encountered in this task was one of degree of specificity. If the response and stimulus are uniquely defined as in most of the accepted reflexes (salivation, knee-jerk, eye-blinking, etc.) then the application to more complex behavior was difficult. If on the other hand, the elements are too generalized, the reflex becomes useless as an experimentally valid unit.[19] The position of compromise is eventually selected by Skinner as that point at which, during experimentation, observed, simple

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[17] Ibid., p. 458. [18] Ibid.

[19] B. F. Skinner, "The Generic Nature of the Concepts of Stimulus and Response," The Journal of General Psychology, XII (1935), 52.

and consistent data can be obtained. This decision is reflected in his operational definition of the reflex:

> A reflex is . . . defined as a correlation of a stimulus and response at a level of restriction marked by the orderliness of changes in that correlation. If this is not an ideally simple definition, it is at least in accord with our data. It is based upon consistency of result rather than exact reproducibility, and it utilizes restriction only in moderation.[20]

Skinner's attention was then drawn to an extension of the reflex concept as proposed by Pavlov,[21] in terms of the conditioned reflex. Figure 13 illustrates Pavlov's familiar formulation (a) in symbolic form and Skinner's additional type of conditioning (b).[22] The conditioning represented in Figure 13(b) is considered by Skinner to be different than that in Figure 13(a) in a number of significant ways.[23] The net result however seems to be that Pavlov's model (Type II) is the more restrictive in its application to behavioral change. Skinner expresses it this way:

> The essence of Type II is the substitution of one stimulus for another, or, as Pavlov has put it, signalization. It prepares the organism by obtaining the elicitation of a response before the original stimulus has begun to act . . . . In Type I there is no substitution of stimuli and consequently no signalization . . . . The conditioned response of Type I [lever-pressing] does not prepare for the reinforcing stimulus, it _produces_ it. The stimulus-to-be conditioned is never in any sense incidental.[24]

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[20] _Ibid_., p. 65.

[21] I. P. Pavlov, _Conditioned Reflexes_, Trans & ed. by G.V.Anrep (London: Oxford University Press, 1927).

[22] B. F. Skinner, "Two Types of Conditioned Reflex and a Pseudo-Type," _The Journal of General Psychology_, XII (1935), 66-69. Figure 13 is taken from this article.

[23] _Ibid_., pp. 67-69. [24] _Ibid_., p. 77.

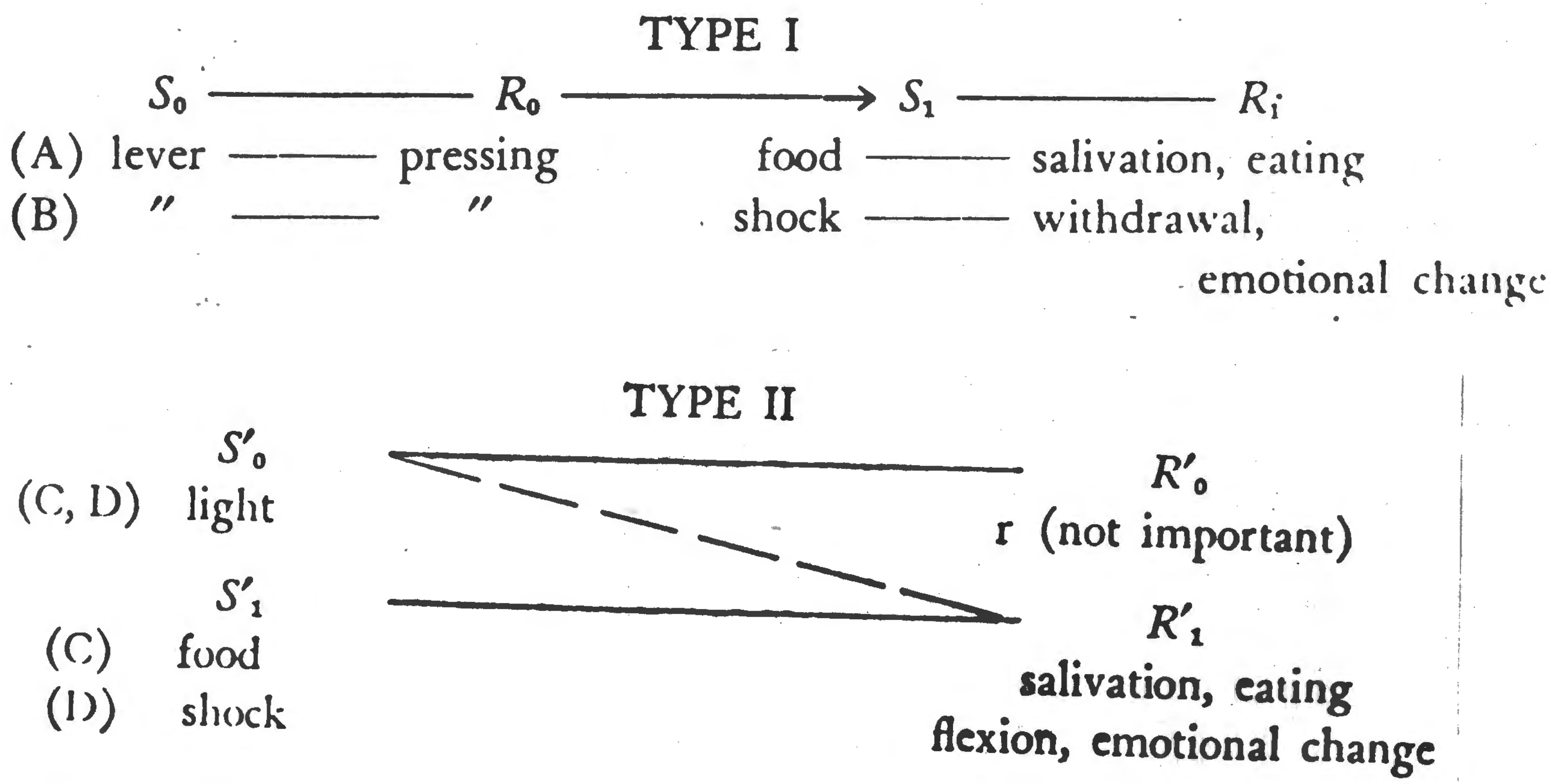

Fig. 13.--Conditioning models

Although it was stated after the fact in a foreword to a reprint of this article in a later volume, Skinner relates the significance of the formulation of Type I in his search for a basic model for learning.

> The principle of conditioning had been advanced by Pavlov to explain all learned behavior. Many American psychologists, particularly the behaviorists, had come to use the term in the same comprehensive sense. But an act acquired through what Thorndike called "Law of Effect" learning could not be interpreted as a conditioned reflex without straining the Pavlovian notion of signalization or substitution of stimuli.[25]

It is worthwhile to note at this point certain identifiable characteristics of Skinner's early approach to the study of behavior which bear significantly on his later contribution to the development of an instructional technology.

1) He was searching for a scientific base for the study of behavior.
2) He was not prepared to accept hypothetical constructs.
3) He placed great emphasis on observed data and relationships.
4) He was greatly interested in the process of learning.

<u>Phase Two (1937-1950) - Consolidation</u>

The first phase of Skinner's work was one of orientation in which he developed an approach to the study of behavior destined to pervade all his subsequent research and writing. Phase two was one of consolidation of certain

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[25]B. F. Skinner, <u>Cumulative Record</u> (New York: Appleton-Century-Crofts, Inc., 1961), p. 367.

elements of a behavioral system. While Skinner himself admits that some of the early work was no longer relevant[26], certain developments in phase two have been shown to be very fruitful in view of later works. The most significant of these relates to the two paradigms of conditioning previously cited. (Type I and Type II). Skinner states:

> . . . there are responses uncorrelated with observable stimuli - a statement which must not be made lightly but cannot, so far as I can see, be avoided. It is a necessary recognition of the fact that in the unconditioned organism two kinds of behavior may be distinguished.[27]

The two kinds of behavior were labelled Type S and Type R to denote the point of emphasis in each. Type S refers to behavior resulting from the contingent relationship between a reinforcer and the eliciting <u>stimulus</u> as first described by Pavlov and illustrated in figure 13 on page 64 of this chapter. Type R represents conditioning which occurs as the result of the contingency of a reinforcing stimulus upon an emitted response. Type I of figure 13 represents Type R when one considers that the eliciting stimulus (S) either " . . . (a) cannot be identified, (b) may be omitted, or (c) may disappear."[28]

In retrospect, the identification of Type R (operant) conditioning and the considerable quantity of research it encouraged could be termed a "breakthrough" in behavioral science. It has been recognized as a definite break with

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[26] B. F. Skinner, "Two Types of Conditioned Reflex: A Reply to Konorski and Miller," <u>Journal of General Psychology</u>, XVI (1937), 273.

[27] <u>Ibid</u>. [28] <u>Ibid</u>.

the traditional approach to the reflex concept by many writers including Hilgard and Bower[29] and Hill.[30] It encouraged dealing with responses without resorting to the often hopeless search for the elicitory stimulus or class of stimuli. It served also to focus attention on the observable elements of behavior and the effects of the conditioning process, thereby broadening the research on the nature of learning.

Following the formulation of operant conditioning Skinner completed a text in which he restated his position on the reflex, the operant, and the conditioning process at some length. The purpose of this text was stated as follows:

> The two questions which immediately present themselves are: What will be the structure of a science of behavior? and How valid can its laws be made? . . . . I am interested, first, in setting up a system of behavior in terms of which the facts of a science may be stated and, second, in testing the system experimentally at some of its more important points.[31]

It is not intended here to cover in any detail, the data presented in the first structural formulation of Skinner's position. The basis of the text is the operant conditioning paradigm with emphasis on the various experiments designed and carried out to provide data respecting certain characteristics of this Type R conditioning. In the process a clarification of the operant is accomplished,[32] and two laws of

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[29]Hilgard and Bower, op. cit., p. 108.

[30]Winnifred F. Hill, "Contemporary Developments within Stimulus-Response Learning Theory," Theories of Learning and Instruction ed. Ernest R. Hilgard (Chicago: The University of Chicago Press, 1964), p. 39.

[31]B.F. Skinner, The Behavior of Organisms (New York: Appleton-Century-Crofts, 1938), p. 5.

[32]Ibid., pp. 19-20.

Type R conditioning are stated:

> The Law of Conditioning of Type R. If the occurrence of an operant is followed by presentation of a reinforcing stimulus, the strength is increased.
> The Law of Extinction of Type R. If the occurrence of an operant already strengthened through conditioning is not followed by the reinforcing stimulus, the strength is decreased.[33]

The text then concentrates on many experimental studies carried out by Skinner in support of his belief that the science of behavior must be developed in terms of observed relationships with regard to:

> . . . (1) the definition of behavior as that part of the activity of the organism which affects the external world; (2) the practical isolation of a unit of behavior; (3) the definition of a response as a class of events; and (4) the demonstration that the rate of responding is the principal measure of the strength of an operant.[34]

The most interesting experiments reported are those which study response rate and the operant strength it indicates. The applications of reinforcement and its effect on operant strength illustrate the type of lawful relationships Skinner was endeavouring to establish. Two methods of application seem to stand out; one related to timing of reinforcement (interval reinforcement[35]) and the other related to application of reinforcement when a certain number of responses had been emitted (ratio reinforcement[36]). It should be noted that in a later text, data for more than 900 experiments using various schedules of reinforcement are presented[37]

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[33]*Ibid.*, p. 21. [34]*Ibid.*, p. 58. [35]*Ibid.*, p. 116.

[36]*Ibid.*, p. 271.

[37]C. S. Ferster and B. F. Skinner, *Schedules of Reinforcement* (New York: Appleton-Century-Crofts, 1957), pp.3-7.

emphasizing the importance placed on the study of modes of reinforcement in operant conditioning.

Another facet of the work done by Skinner during this period is relevant to future developments in the shaping of behavior. This process involving response differentiation represented Skinner's answer to the learning of complex behavior.[38] Great care was exercised in the provision of reinforcement to ensure that only those responses which progressively led to the complex behavioral response desired were reinforced. Some of Skinner's more impressive displays of animal learning put on before his students at Harvard were advanced examples of this technique of complex behavior shaping.[39]

Up to this point in Skinner's writings and experimentation, human behavior had rarely been mentioned. Only the behavior of the laboratory rat had received any attention. Skinner recognized that others would view this as a great weakness and he hastened to point out that his research efforts to-date could be related to human behavior and offered this comment in support of his position at that time.

> The importance of a science of behavior derives largely from the possibility of an eventual extension to human affairs. But it is a serious, though common, mistake to allow questions of ultimate application to influence the development of a systematic science at an early stage. . . . It would . . . have been possible to suggest applications

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[38]B. F. Skinner, The Behavior of Organisms, ibid., pp. 339-40.

[39]Hilgard and Bower, op. cit., p. 144.

> to human behavior in a limited way at each step . . . .. This book represents nothing more than an experimental analysis of a representative sample of behavior. Let him extrapolate who will.[40]

In the final year of this phase, Skinner "extrapolated" extensively in a book[41] in which most of the results of his research and analysis in the field of behavior were restated in a very readable fashion in terms of the human organism. Two developments not considered elsewhere are presented in this interesting text.

1) In the process of operant conditioning it was suggested that stimuli paired with certain basic primary reinforcers such as food, water, or other events of biological importance, would become reinforcing (secondary reinforcement). If such a secondary reinforcer is closely related to a number of primary reinforcers, it becomes a generalized reinforcer which can be employed in shaping behavior in many learning situations. Skinner suggests that attention of others, approval of others, affection of others, the submissiveness of others in certain limited situations, and money are representative of the class of generalized reinforcers.[42] This concept is critical in the application of oper-

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[40]B. F. Skinner, The Behavior of Organisms, ibid., pp. 441-42.

[41]B. F. Skinner, Science and Human Behavior (New York: The MacMillan Company, 1953).

[42]Ibid., pp. 76-81.

ant conditioning to behavioral changes in human beings. There seems to be little doubt that primary reinforcers do affect human behavior but larger areas of behavioral change would appear to be under the control of generalized reinforcers.

2) Skinner deals at some length with the issue of control which is a natural concomitant to a science of behavior. He states:

> An analysis of the techniques through which behavior may be manipulated shows the kind of technology which is emerging as the science advances, and it points up the considerable degree of control which is currently exerted. The problems raised by the control of human behavior obviously can no longer be avoided by refusing to recognize the possibility of control.[43]

He follows this with a consideration of the characteristics of self and group control in the light of reinforcement and operant conditioning.[44] He then discusses the methods employed by certain agencies such as the government, religious institutions, the cultural system, and educational system which have a vested interest in human behavior and which play a controlling role with respect to human behavioral changes.[45]

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[43] Ibid., pp. 227. [44] Ibid., pp. 228-329.

[45] Ibid., pp. 333-412.

The educational agency is of greatest interest in this dissertation. While the discussions of the effective role of education is very brief, it becomes obvious that Skinner is not convinced of the efficiency of this agency. He criticizes the educators for their failure to ensure that the benefits of education will be reinforcing to those who provide financial backing and for their continued use of aversive means of control.

Phase Three 1954-Present - Application

During this phase, application of laboratory findings to human learning processes is presented. In this development of applied research, one sees more clearly the contribution Skinner has made to a technology of learning.

Skinner, like Pressey, is very critical of educational approach and practice. He considers that five principal shortcomings are worthy of mention.[46]

1) The modern progressive educational system has not moved from corporal punishment to positive means of control but rather from one form of aversive control to another. Examples of the aversive control being employed are teacher's displeasure, the criticism or ridicule of classmates, low marks, a trip to the principals' office, or a word to the parents.

2) Long periods of time usually elapse between the

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[46] B. F. Skinner, "The Science of Learning and the Art of Teaching," Harvard Educational Review XXIV, (Spring, 1954), 89-97.

emission of a response and the reinforcement which could increase response probability and eventually ensure retention. The time which elapses between doing an assignment or a test and receiving mark or comment is an example.

3) In many teaching-learning situations there seems to be little consideration given to a skillful program which moves through a series of progressive steps to the final behavior desired. This involves careful analysis of the desirable behavioral changes to be developed and the logical steps which will lead naturally to the final desired behavior.

4) The amount of reinforcement provided by the teacher (the principal source) is extremely small considering the number of responses the student is expected to emit during the run of a year. Skinner suggests, for example, that as many as 50,000 response-reinforcement contingencies would be a reasonable number to ensure that an optimum mathematics repertoire was developed by a student over a period of years.

5) There is a definite lack of evidence that research in the field of learning has been respected or used in the average classroom in an organized, scientific fashion.

Skinner sums up his critique as follows:

> The teacher is usually no happier about this than the pupil. Denied the opportunity to control via the birch rod, quite at sea as to the mode of operation of the few techniques at her disposal, she spends as little time as possible on drill subjects and eagerly subscribes to philosophies of education which emphasize material of greater inherent interest . . . . Eventually, weakness of technique emerges in the disguise of a reformulation of the aims of education. Skills are minimized in favour of vague achievements - educating for democracy, educating the whole child, educating for life, and so on. And there the matter ends; for, unfortunately, these philosophies do not in turn suggest improvements in techniques. They offer little help in the design of better classroom practices.[47]

Thile this is a very harsh criticism, there would appear to be enough truth in it to warrant attention. It is discouraging to note also that Skinner sees little improvement since Pressey's similar, but not as specific, attack almost 30 years before. Skinner goes on to propose a means of alleviating some of the weaknesses by a practical implementation of operant conditioning principles.

One of the most important of these principles is that of reinforcement which can be defined empirically by simply describing the fact that certain environmental effects strengthen the behavior which has produced these effects. These environmental effects are typically referred to as reinforcements. Novelty, praise and material tokens have already been suggested as generalized reinforcers. The effectiveness of reinforcement depends upon the nature of the relationship between the behavioral response and the reinforcement (contingency). When the environmental effects which are reinforcing are fed back to the behaving organisms, reinforcement

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[47] *Ibid*., p. 93.

is effective. When there is a delay, sometimes of only a few seconds, the reinforcing effect is greatly weakened or even eliminated. Thus in teaching a given response, the reinforcement must follow that response very closely. If the particular response is simply one of many responses occurring prior to reinforcement, much unwanted or irrelevant behavior will be reinforced. Therefore, in teaching complex behaviors, which include many different responses, it is necessary to use a series of progressive approximations, with each step in the series being reinforced so to lead finally to the complex behavior in question. By giving reinforcement for each of the responses in the series making up the complex pattern, the desired behavior is gradually shaped. Furthermore, reinforcing each response assures that the learner will receive a large number of reinforcements, thus maintaining his interest and attention.[48]

Skinner then proposes that the most efficient way to take advantage of the principle of reinforcement in educational practice is to employ electrical or mechanical devices, now generally referred to as teaching machines. He claims that only in this way can one economically arrange the optimum conditions of reinforcement, the conditions of immediacy, precision and frequency. With an automated device, the progressive approximations, so important in the shaping of complex behavior, can be programmed.[49]

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[48] *Ibid*., p. 94.

[49] B. F. Skinner, "Teaching Machines," *Science* CXXVIII (1958), 970.

A sample sequence from a program produced by Skinner is provided in Figure 14.[50] The manner in which he purports to shape behavior by operant conditioning can be seen in this example. At first glance it appears as if the subject matter has merely been separated into sentences with key words omitted. However a closer look at the pattern reveals that this is not so. The material has been presented in the form of a developing sequence of behavioral elements, normally referred to as "frames". The behavior being sought in each frame of this program is a verbal response to be constructed by the student. Each frame is designed to ensure a low error rate with members of the student population for whom the program is designed. Contingent upon the student's response is the immediate presentation of reinforcement in the form of the correct response. As the student progresses through the programme frame by frame, reinforced at every step, he develops a repertoire of terms as well as a conceptual knowledge of the nature of "light" through the process of operant conditioning. Behavioral changes occur all along the way and learning takes place.

Figure 15 is an illustration of a machine in which the programmed sequence was used.[51] The machine was designed so that one frame of material was presented in the left-hand window. The student constructed his response in writing on a strip of paper exposed at the right. He then lifted a

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[50] Ibid., p. 974. Figure 14 taken from this article.

[51] Ibid., p. 971. Figure 15 taken from this article.

PART OF A PROGRAM IN HIGH SCHOOL PHYSICS. THE MACHINE PRESENTS ONE ITEM AT A TIME. THE STUDENT COMPLETES THE ITEM AND THEN UNCOVERS THE CORRESPONDING WORD OR PHRASE SHOWN AT THE RIGHT

Sentence to be completed	Word to be supplied
1. The important parts of a flashlight are the battery and the bulb. When we "turn on" a flashlight, we close a switch which connects the battery with the ——.	bulb
2. When we turn on a flashlight, an electric current flows through the fine wire in the —— and causes it to grow hot.	bulb
3. When the hot wire glows brightly, we say that it gives off or sends out heat and ——.	light
4. The fine wire in the bulb is called a filament. The bulb "lights up" when the filament is heated by the passage of a(n) —— current.	electric
5. When a weak battery produces little current, the fine wire, or ——, does not get very hot.	filament
6. A filament which is *less* hot sends out or gives off —— light.	less
7. "Emit" means "send out." The amount of light sent out, or "emitted," by a filament depends on how —— the filament is.	hot
8. The higher the temperature of the filament the —— the light emitted by it.	brighter, stronger
9. If a flashlight battery is weak, the —— in the bulb may still glow, but with only a dull red color.	filament
10. The light from a very hot filament is colored yellow or white. The light from a filament which is not very hot is colored ——.	red
11. A blacksmith or other metal worker sometimes makes sure that a bar of iron is heated to a "cherry red" before hammering it into shape. He uses the —— of the light emitted by the bar to tell how hot it is.	color
12. Both the color and the amount of light depend on the —— of the emitting filament or bar.	temperature
13. An object which emits light because it is hot is called "incandescent." A flashlight bulb is an incandescent source of ——.	light
14. A neon tube emits light but remains cool. It is, therefore, not an incandescent —— of light.	source
15. A candle flame is hot. It is a(n) —— source of light.	incandescent
16. The hot wick of a candle gives off small pieces or particles of carbon which burn in the flame. Before or while burning, the hot particles send out, or ——, light.	emit
17. A long candlewick produces a flame in which oxygen does not reach all the carbon particles. Without oxygen the particles cannot burn. Particles which do not burn rise above the flame as ——.	smoke

Fig. 14.--Sample of Skinner programmed sequence.

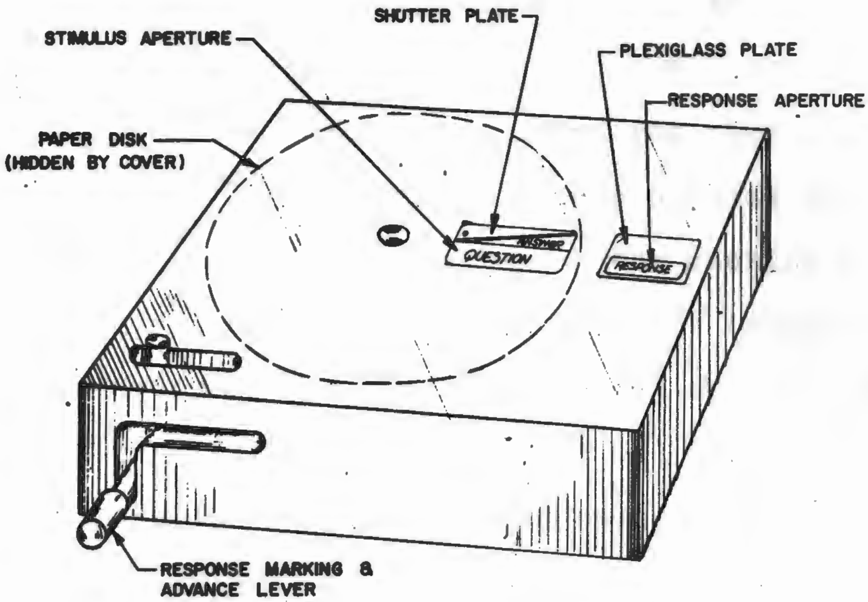

Fig. 15.--A Skinner teaching machine.

lever with his left hand, advancing his written response under a transparent cover and uncovering the correct response in the upper corner of the frame. If he was right, he moved the lever to the right, punching a hole alongside the response he had called right and altering the machine so that the frame would not appear again when he went through the series a second time. A new frame appeared when the lever was returned to its starting position. The machine's only purpose is to control the interaction between student and the programmed material in such a way that learning conditions are optimum.

A recent more extensive example of Skinner's technique is available in a programmed text[52] which was developed and has been used without a machine. It should be noted that this was a change in approach which de-emphasized the need for mechanical control, with the student controlling the provision of reinforcement to a greater degree. The programmed material, however, was prepared and presented in much the same form as that illustrated in Figure 14. Lysaught and Williams[53] have summarized the characteristics of programmed learning, as Skinner proposed it, in the following manner.

1) Assumptions clearly stated with regard to the students' reading ability, working vocabulary and background.

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[52]James G. Holland and B. F. Skinner, The Analysis of Behavior (New York: McGraw-Hill, 1961).

[53]Jerome P. Lysaught and Clarence M. Williams, A Guide to Programmed Instruction (New York: John Wiley and Sons, Inc., 1963), pp. 17-19.

2) Explicitly stated objectives in operational, observable and measurable terms.

3) Logical sequence of small steps developed as a result of analysis of the behavior to be achieved to simplify the acquisition of knowledge, reduce the number of student errors and develop a gradual increase in behavioral complexity.

4) Active responding to ensure that there is a continuous interaction between student and the programmed material.

5) Immediate feedback of information with the stipulation that the more rapidly this feedback is supplied following the response, the more effective becomes the reinforcement or extinction, as the case may be. The student learns from the consequences of his responding, not from the making of responses itself.

6) Individual rate whereby the student proceeds according to his own accomplishments.

7) Constant evaluation of the programme in terms of student error rate, progress towards objectives and remedial requirements.

Comprehensive discussions of these principal characteristics can be found in articles by Holland[54] and Schramm[55] as well as in a text by Taber, Glaser and Shaefer[56]. Following Skinner's early proposals and examples of the application of operant conditioning in the classroom, many programmes were produced which were intended to exemplify the aforementioned characteristics. Typical papers describing these early efforts were published by Skinner and Holland,[57] Ferster and Sopan[58] Porter,[59] Meyer[60] and Hively[61] all members of the Harvard

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[54]James G. Holland, "Teaching Machines: An Application of Principles from the Laboratory," Teaching Machines and Programmed Learning ed. A. A. Lumsdaine and Robert Glaser (Washington: National Education Association, 1960), pp. 219-225.

[55]Wilbur Schramm, "Programmed Instruction Today and Tomorrow," Four Case Studies of Programmed Instruction, ed. Wilbur Schramm (New York: The Fund for the Advancement of Education, 1964), pp. 98-100.

[56]Julian I. Taber, Robert Glaser and Halmuth H. Shaefer, Learning and Programmed Instruction (Reading: Addison-Wesley, 1965), pp. 1-14.

[57]B. F. Skinner and James G. Holland, "The Use of Teaching Machines in College Instruction," in Teaching Machines and Programmed Learning, op. cit., pp. 159-172.

[58]Charles B. Ferster and Stanley M. Sapon, "An Application of Recent Developments in Psychology to the Teaching of German," Harvard Educational Review XXVIII (Winter, 1958), 58-69.

[59]Douglas Porter, "A Report on Instructional Devices in Foreign Language Teaching," Teaching Machines and Programmed Learning, op. cit., pp. 186-205.

[60]Susan R. Meyer, "Report on the Initial Test of a Junior High-School Vocabulary Program," Teaching Machines and Programmed Learning, ibid., pp. 229-246.

[61]Wells Hively, "An Exploratory Investigation of an Apparatus for Studying and Teaching Visual Discrimination, Using Preschool Children," Teaching Machines and Programmed Learning, ibid., pp. 247-256.

Group. A survey by Rigney and Fry[62] in 1961 covering 80% of all the programs produced up to that time, provides a discussion of the principles and characteristics of instructional programming together with sample pages from 58 Skinner-type programs. These examples provide a cross-sectional view of applications of operant conditioning over a wide range of subject matter. Also four excellent case studies on the use of programmed learning in selected American schools reported by Schramm[63] are worth reading for they provide valuable insight into the problems of implementation of early Skinner-type programs in public school systems.

It is not the intent of this thesis to discuss the validity of Skinner's behavioral theory or to make a value judgement on the programs produced by him, his associates or his advocates. Much has been written on both these subjects and it is left to others to carry out research into the pros and cons of his approach. One example of just such a project is the thesis by Shields[64] which deals with Skinner and programmed learning from the humanistic point of view.

In spite of the philosophical, psychological, and

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62 Joseph W. Rigney and Edward B. Fry, A Survey and Analysis of Current Teaching - Machine Programs and Programming, Technical Report No. 31 prepared for Personnel and Training Branch, Psychological Sciences Division, Office of Naval Research (Los Angeles: University of Southern California, 1961), pp. 56-145.

63 Wilbur Schramm, (ed.) Four Case Studies of Programmed Instruction (New York: The Fund for the Advancement of Education, 1964), pp. 18-94.

64 William S. Shields, "A Humanistic Evaluation of Programmed Instruction," (M. A. Thesis, Saint Mary's University, Halifax, April 1, 1964).

educational arguments which Skinner's work has aroused, certain factors from the description contained herein clearly support his position as a leader in the field of instructional technology.

1) He developed, by laboratory research, certain concepts which stressed the emitted observeable responses of the learning organisms rather than the eliciting stimuli or the mediatory process. In this way he isolated elements and process of behavior which could be brought under practical control.
2) His belief that desired behavioral changes could be "shaped", naturally led to careful consideration of the nature of the behavior desired in both the laboratory and in the classroom.
3) In dealing with complex forms of human behavior he has adopted the process of approximation which involves a precise behavioral analysis to determine the behavioral elements which progress toward the gross behavioral change desired.
4) He contends that the only measure of success in shaping behavior is the ability of the organism to perform according to specifications at the completion of the "shaping" process.
5) He and his associates produced instructional materials and devices based on these factors, and students, who used them, learned. This is no longer just a claim, it is a fact. In 1964,

Schramm reviewed some 165 research papers on programmed learning and stated that the evidence clearly indicated that students do learn from programmed instruction.[65] This is only one of several surveys which resulted in the same conclusion.

6) The practical application of operant conditioning in the form of programmed learning has served to re-emphasize the importance of the student and his success in learning. One must agree with Crowder when he asks " . . . what teacher ever deliberately organized his material in any other way than the one which he believed would ultimately promote student learning?"[66] However Skinner's approach has indicated a practical way to increase the probability of optimum student learning. The discipline of producing and validating programmed instructional materials demands a much higher degree of attention to the student requirements and his subsequent success or failure than normally given in the traditional

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[65]Wilbur Schramm, The Research on Programmed Instruction An Annotated Bibliography, cited by E. R. Hilgard and G. H. Bower, Theories of Learning (3d ed.; New York: Appleton-Century-Crofts, 1966), p. 558.

[66]Norman A. Crowder, "Programmed Instruction Compared With Automated Instruction," in Trends in Programmed Instruction ed. Gabriel D. Ofiesh and Wesley C. Meierhenry, (Washington: Department of Audiovisual Instruction, National Education Association of the United States, 1964), p. 28.

approach. Also, the programmed learning approach provides a reproducible and proven means of ensuring student learning, which should be the desire of all teachers and instructors.

The advent of programmed learning based on Skinner's approach led to many variants. However one approach which did not develop along operant conditioning lines was that of Norman A. Crowder. It is worth considering the work of Crowder which supports Hilgard's suggestion that " . . . programming is no more a single line of development than the teaching machine is a single type of equipment".[67]

Norman A. Crowder

Crowder's interest in programming began in 1955 when, employed as a training consultant to the United States Air Force, he was doing research on problems encountered in the training of electronic technicians in the technique of trouble-shooting. In the process he developed a training device by which the student was provided with sequences of troubleshooting problems and multiple-choice questions, the responses for which led him to new items and sequences.[68] The nature of troubleshooting as a series of possible symptoms and causes would appear to have led Crowder to use a questioning technique in which the student had to make initial choices and then proceed on the basis of such choices. It

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[67]Hilgard and Bower, op. cit., p. 557.

[68]A. A. Lumsdaine, "Teaching Machines: An Introductory Overview," Teaching Machines and Programmed Learning, op. cit., pp. 20-21.

will be recalled that Pressey also used the multiple-choice question as a response mode and it is seen here again.

From this work, Crowder developed programmed instructional materials in several other fields using a similar approach which he describes in the following manner:

> The student is given the material to be learned in small logical units (usually a paragraph, or less, in length) and is tested on each unit immediately. The test result is used automatically to conduct the material that the student sees next. If the student passes the test question, he is automatically given the next unit of information and the next question. If he fails the test question, the preceding unit of information is reviewed, the nature of his error is explained to him, and he is retested. The test questions are multiple-choice questions, and there is a separate set of correctional materials for each wrong answer that is included in the multiple-choice alternatives. The technique of using a student's choice of an answer to a multiple-choice question to determine the next material to which he will be exposed has been called "intrinsic programming".[69]

The format and approach of intrinsic programming is illustrated with an example from such a programme in figures 16 and 17[70] on the next two pages. A brief glance will clearly illustrate the manner in which the program uses the multiple-choice response mode to determine the next material the student should see. If a more complete sequence is desired, Crowder's The Arithmetic of Computers[71] is a particularly good example. Figure 18 provides the sequencing

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[69]Norman A. Crowder, "Automatic Tutoring by Intrinsic Programming," Teaching Machines and Programmed Learning, ibid., p. 286.

[70]Ibid., pp. 289-291. Figures 16 and 17 have been taken from this article for the purpose of illustration.

[71]Norman A. Crowder, The Arithmetic of Computers (New York: Doubleday Co., Inc., 1960). This text is of historic interest as it was the first "book" version of an intrinsic programme.

Page 101:

Now, you recall that we had just defined

$$b^0 = 1$$

for any b except where $b = 0$. We had reached this definition by noting that our division rule,

$$\frac{b^m}{b^n} = b^{(m-n)}$$

will give b^0 as a result if we apply it to the case of dividing a number by itself. Thus,

$$\frac{b^3}{b^3} = b^{(3-3)} = b^0$$

but

$$\frac{b^3}{b^3}, \text{ or any number (except 0),}$$

divided by itself equals 1, so we defined $b^0 = 1$.
We used a division process to find a meaning to attach to the exponent 0. Very well, let's see what other interesting results we can get with this division process. Let's apply our division rule to the case of $\frac{b^2}{b^3}$. What result do we get?

ANSWER	PAGE
$\frac{b^2}{b^3} = b^1$	94
$\frac{b^2}{b^3} = b^{(-1)}$	115
The rule won't work in this case	119

The student who elects page 94 will find:

Page 94:

YOUR ANSWER: $\frac{b^2}{b^3} = b^1$

Come, come, now. The rule is

$$\frac{b^m}{b^n} = b^{(m-n)}.$$

Now, in the case of

$$\frac{b^2}{b^3},$$

we have $m = 2$ and $n = 3$, so we are going to get

$$\frac{b^2}{b^3} = b^{(2-3)}.$$

So, $2 - 3$ isn't 1, is it? It's -1.

Return to Page 101, now, and quit fighting the problem.

Fig. 16.--A Crowder programmed sequence

And the student who chooses the right answer will find:

Page 115:

YOUR ANSWER: $\frac{b^2}{b^3} = b^{(-1)}$

You are correct. Using our rule for division

$$\frac{b^m}{b^n} = b^{(m-n)}$$

in the case of

$$\frac{b^2}{b^3}$$

we get

$$\frac{b^2}{b^3} = b^{(2-3)} = b^{(-1)}.$$

Now, by ordinary arithmetic, we can see that

$$\frac{b^2}{b^3} = \frac{b \times b}{b \times b \times b} = \frac{\not b \times \not b}{\not b \times \not b \times b} = ?$$

So how shall we define $b^{(-1)}$?

ANSWER	PAGE
$b^{(-1)} = \frac{0}{b}$	95
$b^{(-1)} = \frac{1}{b}$	104

The student who elects page 119 will find:

Page 119:

YOUR ANSWER: The rule won't work in this case.

Courage! The division rule got us through b^0, where $m = n$, and it will get us through the case where m is smaller than n. In this case we have

$$\frac{b^2}{b^3} = ?$$

and applying the rule

$$\frac{b^m}{b^n} = b^{(m-n)}$$

we get

$$\frac{b^2}{b^3} = b^{(2-3)}.$$

So the exponent of our quotient is (2 − 3) which is −1, isn't it? So just write

$$\frac{b^2}{b^3} = b^{(2-3)} = b^{(-1)}$$

as if you knew what it meant.

Now return to Page 101 and choose the right answer.

Fig. 17.--A Crowder programmed sequence (Cont'd)

diagram for the example given above and indicates why this type of programme is often referred to as a "branching" programme. When such a programme is produced in textbook form the term "scrambled book" is used. Figure 19[72] illustrates the first teaching machine designed particularly for Crowder-type programmes. Figure 20[72] illustrates a later model. A paper which reports on the use of the later model of this teaching machine and branching programmes has been written by Stavert of the Royal Navy.[73]

Most writers dealing with the rationale of Crowder's approach usually compare it with Skinner's. Just such a comparison by Lumsdaine provides further insight into the nature of the intrinsic programming method. He states:

> The two approaches Skinner and Crowder have in common the three basic factors of individually paced instruction, active response, and immediate feedback. Also, both attempt to create a self-mastery of a subject when used as the sole or primary vehicle of instruction . . . both tend to be based on a logically sequenced arrangement of the elements of the subject . . . both . . . may be implemented more or less advantageously either with more complex mechanical devices for controlled presentation and regulation of the program, or by means of an inexpensive book-format in which some degree of automaticity and control is sacrificed.[74]

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[72]Figures 18 and 19 provided by Western Design and Electronics Division of U.S. Industries, Inc., for inclusion in this report.

[73]G. S. Stavert, "Programmed Instruction in the Royal Naval Electrical School," Proceedings of the Programmed Learning Conference at Loughborough, April 15-18, 1966 (London: Methuen and Company Ltd., 1967), pp. 167-179.

[74]A. A. Lumsdaine, "The Development of Teaching Machines and Programmed Self-Instruction," abstracted by A. A. Lumsdaine in Teaching Machines and Programmed Learning, op. cit., pp. 653-654.

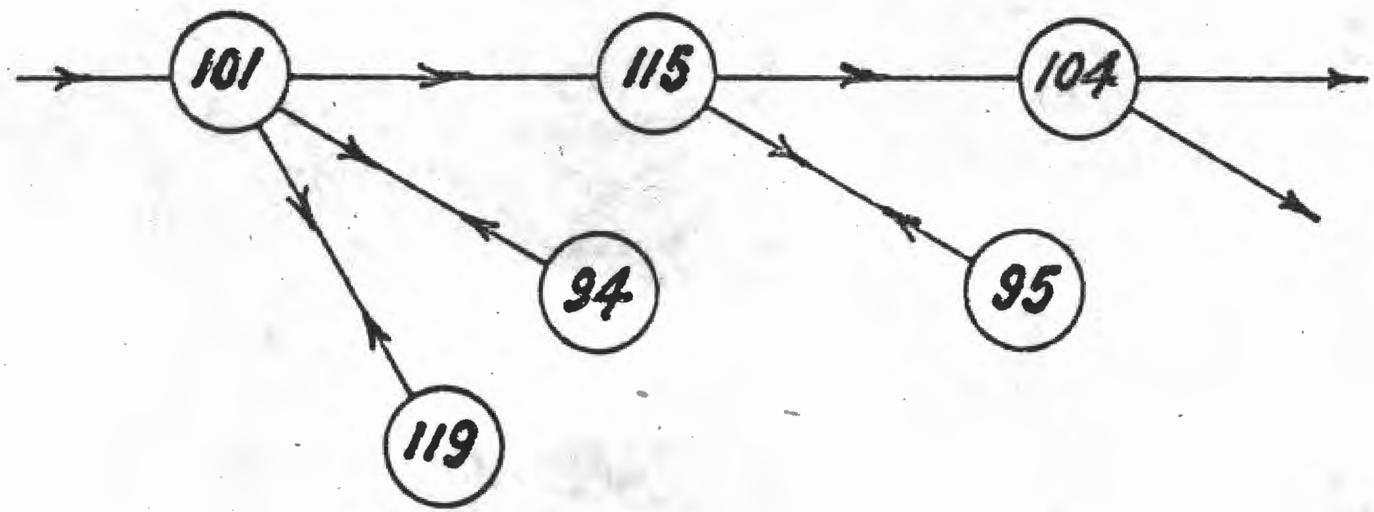
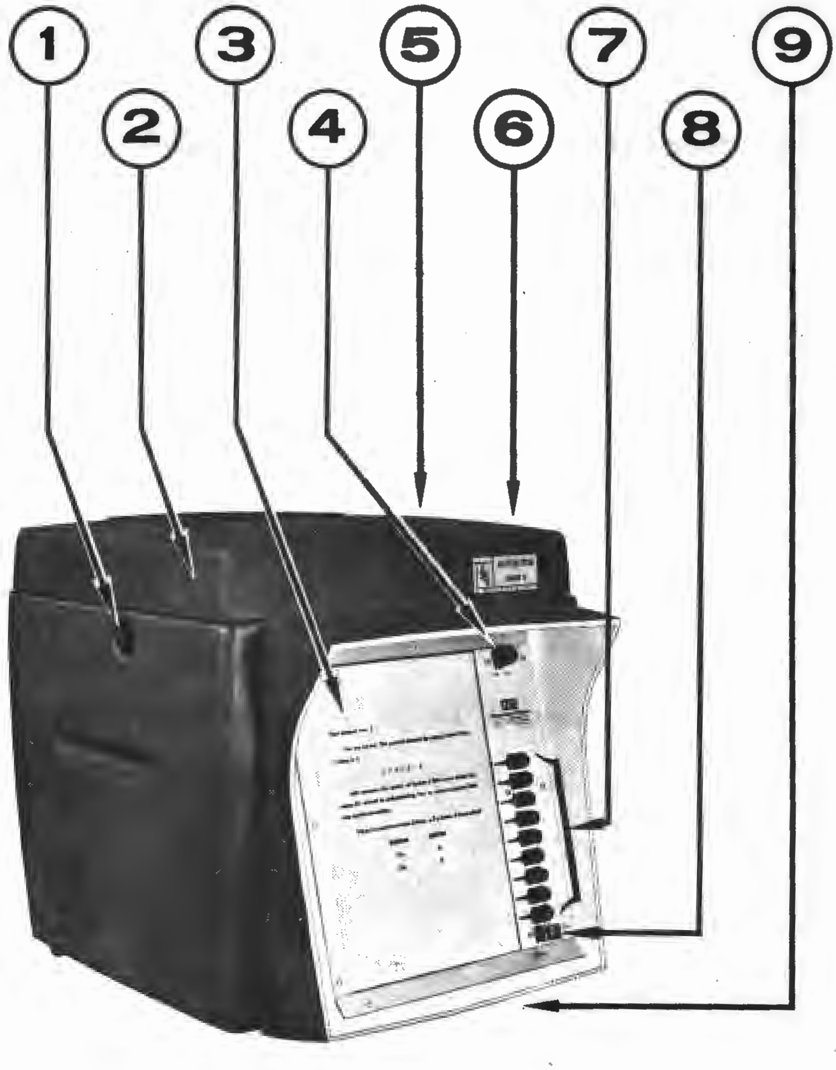


Fig. 18.--A branching sequence diagram

Fig. 19.--Autotutor MK I



(1) FOCUS CONTROL
(2) HOOD
(3) VIEWING SCREEN
(4) ON-OFF SWITCH
(5) ERROR COUNTER (under hood)
(6) KEY LOCK (side of hood)
(7) SELECTOR BUTTONS
(8) RETURN BUTTON
(9) ADJUSTABLE FOOT

Fig. 20.--Autotutor MK II

Lumsdaine goes on to indicate the differences in terms of:

1) Response Mode - Crowder uses multiple-choice while Skinner uses constructed response.
2) Frame or Step Size - Crowder uses longer frames leaving more of the learning up to mediation by implicit rather than overt response, while Skinner keeps frame size small insisting on observable constructed response.
3) Error rate - Crowder makes many of the steps difficult enough to challenge the superior student, allowing remedial steps for those who make errors, while Skinner develops the steps to minimize the number of errors.
4) Learning Rationale - While Crowder uses the response mode to determine the next material the student should see, Skinner insists that the correct student response must be emitted and reinforced every step of the way to ensure a higher probability of learning. It should be added, however, that Crowder is very interested in having the student learn. Materials are very carefully arranged so that the student does receive reinforcement when he gets the right answer and further help if he does not. The correct response is critical in both types of programs.[75]

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[75] Ibid.

Since the response is so important in both types, Crowder suggests that in his programmes, the response should serve to:

A. Determine whether the student has learned the material first presented;
B. Select appropriate corrective material if the student has not learned;
C. Provide desirable practice with the concept involved;
D. Serve to keep the student actively working at the material; and,
E. Presumably, if the student gets the question right, serve a desirable motivational purpose.[76]

Up to this point little has been said about learning theory in regard to Crowder's programming approach. The prime concern has been with characteristics, structure and use of the instructional materials. This would seem to be in line with Crowder's own thoughts on the place of learning theory in his deliberations. He has stated:

> The intrinsic programming theorist will not point to a specific learning model but will rather describe a technique which in common-sense terms, appears to permit inanimate materials to assume some of the educational functions that have previously required a live instructor, or tutor, for each student. Thus while the linear programmer is exploiting a particular theory the intrinsic programmer is exploiting a particular technique.[77]

Later in this same article he admits that he " . . . does not pretend to know in detail <u>how</u> the student learns,

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[76]Norman A. Crowder, "Intrinsic and Extrinsic Programming," A Paper presented at the Conference on Application of Digital Computers to Automated Instruction, Washington, October 10-12, 1961, Co-sponsored by the U.S. Office of Naval Research and the System Development Corporation.

[77]Norman A. Crowder, "On the Differences Between Linear and Intrinsic Programming," <u>Educational Technology</u>, (ed.) John P. DeCecco (New York: Holt, Rinehart and Winston, 1964), p. 144.

but is interested in whether he learns".[78]

In a later article however, he and Walther seem to find it necessary to relate more closely to learning theory. They suggest that " . . . field theory is applied through the effective organization of the material, the step size, the level of difficulty of the question, and the information provided on the wrong-answer pages".[79] This is further detailed to show that the new material is closely related to previously learned material and in this way the student's field becomes extended in this subject area. They then apply the level of aspiration principle to support the multiple-choice response mode. They state:

> The ability of intrinsic programmes to branch the student into his appropriate level maintains his aspirations to succeed. In order to experience success, the student must always be aware of the possibility of failure.[80]

The Gestalt principle of closure is also quoted in support of the value of the correct response. While Skinner has said that the knowledge of being correct is reinforcing and learning is enhanced, Crowder and Walther insist that in intrinsic programming:

> . . . the successful answer to a multiple-choice question provides an immediate and limited closure. Confirmation of the right answer accomplishes the same function in the frames of a linear Skinner program.

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[78]Ibid., p. 148.

[79]R. E. Walther and Norman E. Crowder, A Guide to Preparing Intrinsically Programmed Instructional Materials, Technical Report 65/43 prepared for Aerospace Medical Research Laboratories, Aerospace Medical Division, Wright-Patterson Air Force Base, Ohio, (April, 1965), p. 4.

[80]Ibid.

> However, an endless succession of immediate closures loses its effectiveness in learning situations . . . . A high failure rate on a test fails to achieve closure on the part of the student and a very easy test fails to maintain the student's level of aspiration.[81]

There seems to be little doubt that Crowder's approach relates to the cognitive point of view of human learning. Considering this, it would appear that in addition to developing programmed instructional materials which teach, Crowder's principle contribution to the field of programmed learning in particular and instructional technology in general has been to bring into the fold those who, like himself, have viewed Skinner's linear model as "undesireably restrictive".[82]

The many examples of programmed learning, which have emanated from the work of the three most influential workers in the field, have attracted a great deal of attention. As of December, 1967, the most comprehensive catalogue[83] of existing programs lists 4,036 self-contained units of programmed instructional material available to the public. Table 1 below indicates the numbers and percentages of programs grouped by subject matter areas.

Of all the commercial programs listed in the catalogue, programming style was indicated in only 615 cases. Of these, it is of note that 77% were listed as linear constructed-response (Skinner), 8% were branching, multiple-choice (Crowder), 4% combination linear-branching, and 11%

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81 Ibid., p. 5.

82 Norman A. Crowder, "On the Difference Between Linear and Intrinsic Programming," op. cit., p. 152.

83 Northeastern University, Programmed Instruction Guide (Boston: Entelek Incorporated, 1967), p. 3.

were adjunct (Pressey).

TABLE 1[84]

COMMERCIALLY AVAILABLE PROGRAMS

Subject Matter Areas	Numbers	Percentage[a]
Generalities	30	Less than 1
Philosophy and Related	79	2
Religion	15	Less than 1
Social Sciences	430	10
Language	770	20
Pure Sciences	1,459	36
Technology	946	24
The Arts	89	2
Literature and Rhetoric	68	2
General Geography, History, etc	140	3

[a]Percentages have been rounded off to nearest whole number.

At a recent military institute attended by the writer, the U.S. Armed Forces representatives indicated the extent of their use of Programmed Instruction.[85] The U.S. Air Force has 1,900 hours of programmed instruction in use with 2,300 hours in preparation. In addition to these materials produced mostly "in-house", 145,000 students have received driver training by the EDEX system which is an audio-visual presentation with multiple-choice response made arrangements for each

[84]Letter from Miss Geleta F. Fenton, Director, Office of Educational Resources, Northeastern University, Boston Massachusetts, June 19, 1968. While the catalogue cited above is revised regularly, the data in Table 1 were obtained from Miss Fenton as updated information taken from the data bank of the computer which had just been prepared for the July 1968 revision.

[85]This data reported by service representatives at the Military Institute of the National Society for Programmed Instruction Annual Convention held in San Antonio, Texas, April 17-20, 1968.

student. Further detail on this system and its operation can be found in Appendix B and in a report by Walsh and Reeves.[86] The U.S. Navy (General) has 1,000 hours of programmed instruction in use. Of these 72% are linear, 7% are branching and adjunct and 21% are combinations of these. In the Naval Air Branch, 490 programmed texts are used. In the U.S. Army, 350 programmed texts are in use with 80% of the army schools using programmed instruction in one form or another. In the Canadian Forces a limited number of programmes are being used at present, primarily due to the small number of programmers available to prepare and implement them. The programming effort of one programmed learning unit is described in greater detail in Appendix C to this paper.

The above data, while not telling the complete story, is indicative of the reality of programmed learning as a product. It is the contention of this thesis, however, that it is the process of programming rather than its products *per se*, which holds the greatest promise for the development of an effective instructional technology.

Skinner's careful arrangement of reinforcement contingencies for the shaping of behavior, his penchant for overt responses as the indicators of the desired behavioral steps having been taken and his insistence upon revision of programs content and sequence until the desired behavior pattern has been developed coupled with Crowder's complex branching techniques have given rise to the establishment of a guide

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[86] Clinton Walsh and George T. Reeves, *Report on Edex-ADP Training*, Document 5670(11-66). (Washington: National Training Centre, Internal Revenue Service, 1966).

to the sequenced activities involved in program development. Melching et al.[87] listed the following steps as essential to program development:

1) Specification of objectives of instruction.
2) Development of criterion test.
3) Preparation of teaching outline.
4) Preparation of the program frames.
5) Internal review of the program and revision as required.
6) Preliminary testing of the program and revision as required.
7) Testing the program as an instructional tool and revise as required.
8) Periodic review and revision as required.

Figure 21 illustrates a similar sequence of steps in the programming process and shows the forward and backward relationships of one step with another as proposed by Lysaught and Williams.[88] A more recent sequence is illustrated in Figure 22[89]. While many other process descriptions have been proposed and different methods of programming may combine, subdivide or eliminate certain procedures, the flow illustrated in figure 22 is usually followed.

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[87] William H. Melching, et al., The Text of an Orientation Workshop in Automated Instruction, A consulting report on Subtask TEXTRUCT II prepared for the U.S. Army Air Defence Human Research Unit, Fort Bliss, Texas (July, 1962), pp. 27-38.

[88] Jerome P. Lysaught and Clarence M. Williams, A Guide to Programmed Instruction (New York: John Wiley and Sons Inc., 1963), p. 26. Figure 20 has been taken from this publication.

[89] Programmed Learning - Air Force Manual No. 50-1 (Washington: U.S. Government Printing Office, 1967), p. 12.

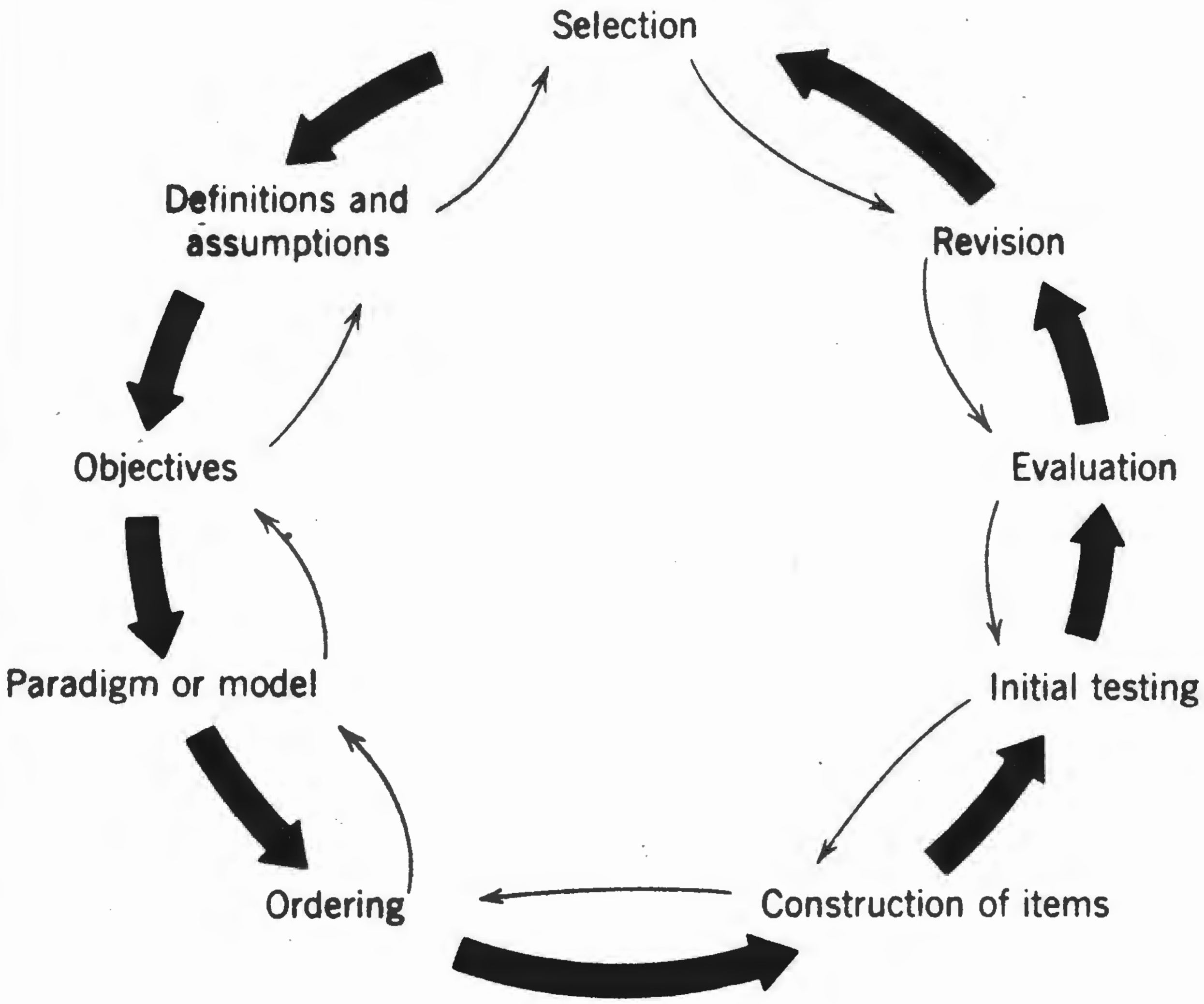

Fig. 21.--Interrelation of steps in programming production sequence

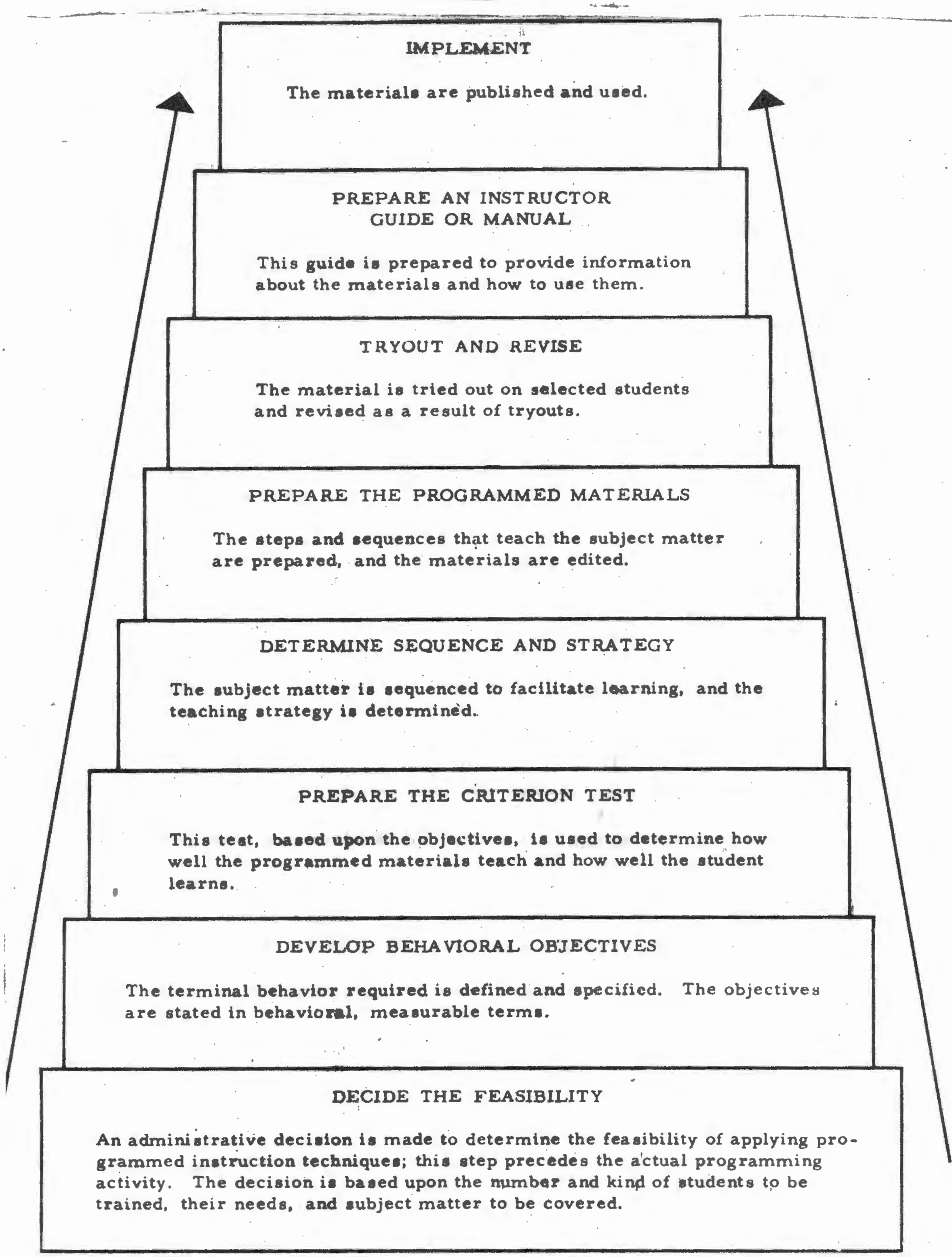

Fig. 22.--Programming production sequence

The process of programming is unique in recognizing and providing for the following:

1) Learning must result in overt and/or covert changes in behavior of the student.
2) Behavioral changes desired must be clearly identified and then translated into behavioral learning objectives which, when achieved by the student, will be indicative of student learning.
3) Achievement of the learning objectives must be assessed by testing for observable concomitants of the desired behavior.
4) Shaping of complex behavior depends on steps and sequences of steps which can only be developed by careful analysis of the structure and nature of the desired behavior.
5) Validation of programmed material must be carried out in terms of student success on the criterion test.
6) Programmed material is considered complete only after it proves to be effective under operational conditions.

Resumé

Ofiesh, one of the outstanding early proponents of programmed learning within the U.S. Air Force Training Command, has stated:

> The best hope for the emergence of instructional, training and educational technology lies in the fullest

exploration of the concept and system of programmed learning and in developing automation procedures.[90]

The position taken by Ofiesh does not seem excessively optimistic in view of the centrality of programmed learning among other facets of the physical and behavioral sciences illustrated in figure 23(a).[91]

This placing of programmed learning at the centre of the development of an instructional technology would appear to be further merited on the basis of several additional observations.

Firstly, the instructional program, as an effective force in a large variety of learning environments, has come of age. Figure 23(b) summarizes its development.[92] It provides a highly structured and completely reproducible learning medium, clearly capable of careful validation in terms of student results. A selected annotated bibliography of articles describing the use and development of programmed learning in a wide span of training and educational situations is provided in Appendix A for the use of readers who may be interested.

Secondly, Hilgard and Bower have argued very persuasively for the need to apply theory to practice. They state:

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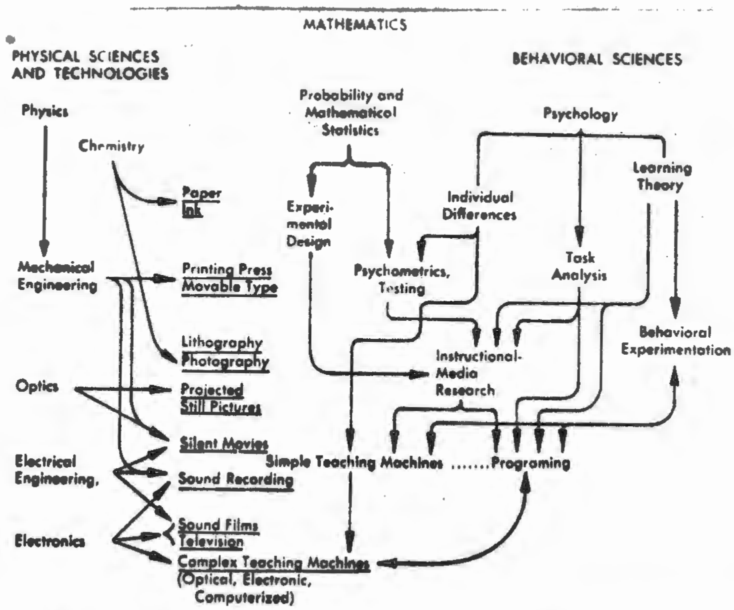
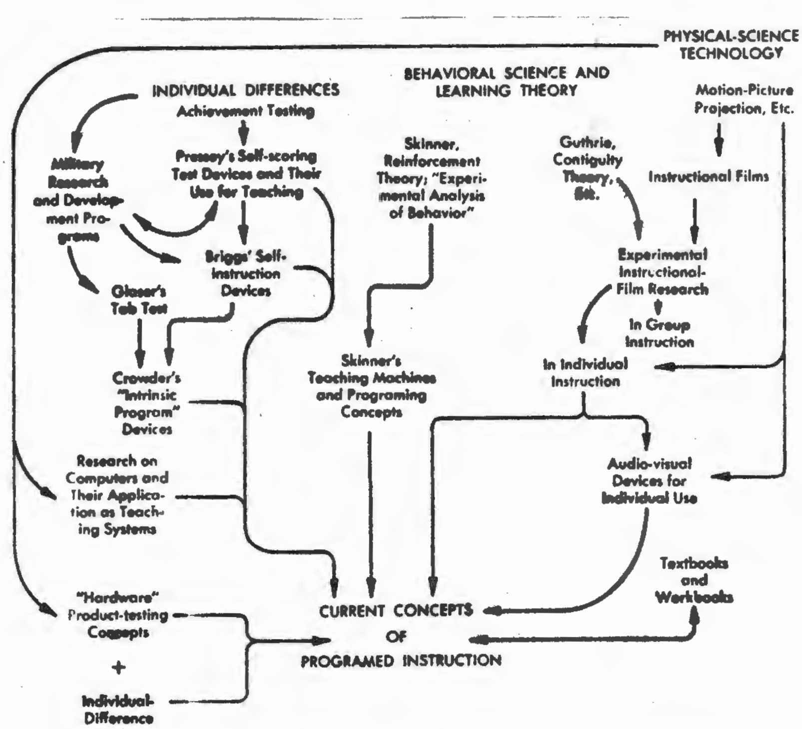
[90]Gabriel D. Ofiesh, Programmed Instruction (New York: American Management Association, 1965), p. 26.

[91]A. A. Lumsdaine, "Educational Technology, Programmed Learning, and Instructional Science," Theories of Learning and Instruction, (ed.), E. R. Hilgard (Chicago: University of Chicago Press, 1964), p. 375.

[92]Ibid., p. 384.



Some of the interrelationships among developments in physical and behavioral sciences related to educational technology.



Converging streams of influence affecting present concepts and practices in programed instruction.

Fig. 23.--Programming and educational technology

> It is now commonly recognized that it is not possible to move from basic science directly to applied science [a technology] without a number of intervening steps, some of which require all the ingenuity and scientific acumen of basic research itself.[93]

Figure 24 illustrates the stages referred to above.[94] The most critical point seems to be between steps three and four. The proven capability of Programmed Learning to carry theoretical principles into the classroom provides a carefully worked-out and validated medium for the bridging of this gap. This is borne out in the following statement:

> . . . too much of the research has rested at Steps 1 and 2 to be educationally relevant; educational psychologists, too, have tended to work at this end of the spectrum and then _to jump by inference, to Step 6, without being sufficiently patient about Steps 4 and 5_. [Italics mine] In this respect the introduction of programmed learning has been helpful, because of the serious concern both with the structure of subject matter and with the individual learner for whom the program is designed.[95]

The program provides a medium for practical application of learning principles in the classroom environment. Four interesting but divergent applications of learning theory in the classroom are briefly described in Appendix B for those readers who may wish to refer to them.

Thirdly, one of the cries of the educator has been that most of the research on human learning has been carried out in the laboratory and the results did not directly apply to the practical classroom environment. The advent of pro-

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[93] Hilgard and Bower, _Theories of Learning_, _op. cit._, p. 573.

[94] _Ibid._, Figure taken from Hilgard and Bower.

[95] _Ibid._, pp. 577-78.

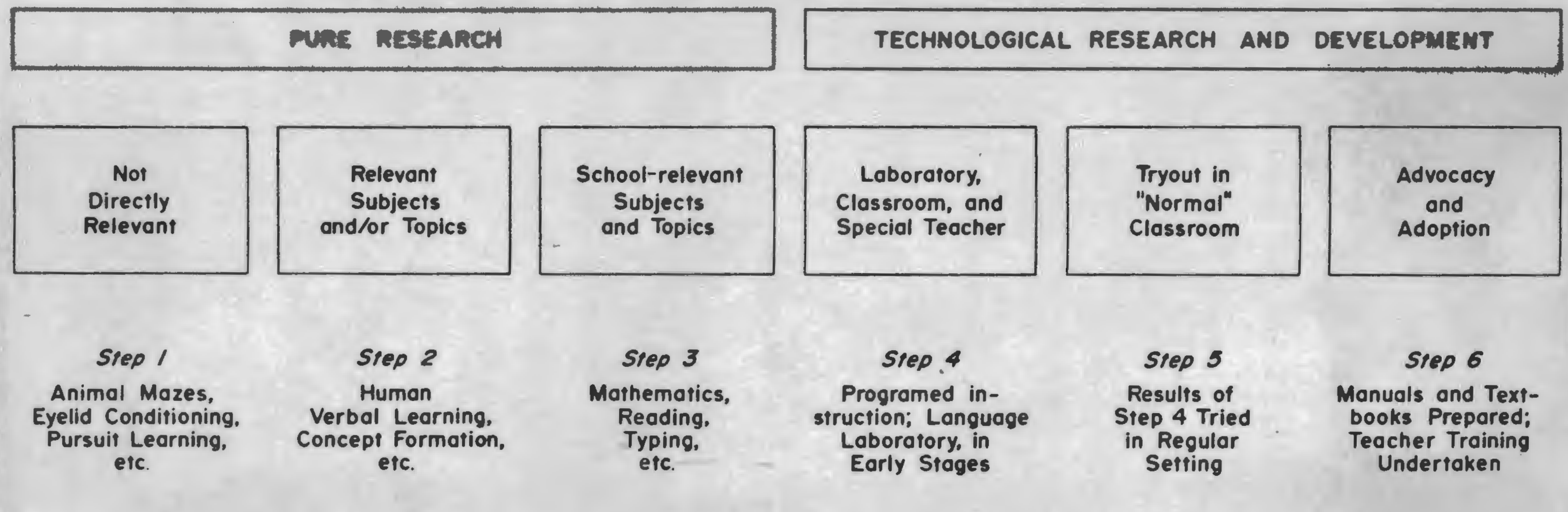

Fig. 24.--Steps in research on learning-pure research to technological development.

grammed learning has made possible the implementation of considerable applied learning research in the classroom. Stolurow states:

> One of the advantages which the teaching machine has over conventional instruction is that it freezes the instructional process during a study in a way which permits it to be used with many individual students. Furthermore, it isolates the instructional material and its plan of organization from the personality of the teacher and related factors which heretofore have always appeared in an inseparable combination with the teaching method. The combination now can be studied as separate components to determine the relative effectiveness of the method independent of those other factors . . .. Through such an approach one should be able to develop a theory of teaching which could guide the classroom teacher, as well as the writer, in developing educational materials along more effective lines.[96]

Table 2 lists a number of studies of the nature suggested by Stolurow which were carried out during 1964-65 at the University of Birmingham using programmed materials.

<u>The program is an effective vehicle for experimental research leading to validation of instructional principles that can ultimately comprise a technology of instruction</u>.

Fourthly, the nature and intent of instructional programs as they have been defined by Skinner, Crowder, and their followers necessitated the development of the disciplined and systematic process described previously. This process clearly suggests that the developer of <u>any</u> instructional design which is to affectively achieve its intent (regardless of the eventual mode(s) of implementation) must adopt a procedure which embraces at least the following

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[96] Lawrence M. Stolurow, "Teaching Machines and Programmed Instruction," <u>The American Behavioral Scientist</u> VI (November, 1962), 43-45.

TABLE 2

EDUCATIONAL RESEARCH PAPERS[97]

Research Note No.	Title	Author
7.	Modes of Responding and Redundancy......................	G.O.M. Leith and K.M. Burke
8.	An Investigation of the Role of Stimulus and Response Meaningfulness in Verbal Learning.....	G.O.M. Leith
10.	Learning in Pairs................	R. Amaria et. al.
12.	The Place of Review in Meaningful Verbal Learning Sequences......	G.O.M. Leith et. al.
13.	Mode of Response and Learner Characteristics................	L.A. Biran et. al.
14.	Mode of Learning and Personality.	G.O.M. Leith and R. Bassett
19.	The Influence of Social Reinforcement and Personality on Achievement in a School Learning Task...................	G.O.M. Leith and T.N. Davis
20.	The Place of Demonstration in Teaching Practical and Verbal Skills.........................	G.O.M. Leith and G.S. Wood
22.	Transfer of Learning as a Function of Task Variation.....	G.O.M. Leith and W.D. Clarke
24.	Relations Between Attainment of Component Skills, Retention and Transfer..................	D. F. Buckle

[97]Letter from G.O.M. Leith, School of Education, National Centre for Programmed Learning, University of Birmingham, Birmingham, England, May 20, 1968. Mimeographed copies of papers listed accompanied the correspondence.

ingredients:

(a) A careful analysis to determine specifically the requirements of the operational environment into which the student is to be graduated.

(b) A development of instructional goals in the form of student-oriented behavioral objectives, achievement of which will prepare the student for effective performance in the operational environment.

(c) An instructional system design based on the stated objectives and the application of validated principles of human learning.

(d) A means of validating the instructional process in terms of student achievement of stated objectives and proven ability of graduate to perform effectively in the operational environment.

Thus programmed learning has provided both a process and a product in support of instructional technology. The process provides guidance and a workable framework for the planning, development and validation of instructional design while the product provides one successful technique for its implementation.

The chapter which follows describes the development of an approach to the whole gamut of training and educational activities, which exemplifies the programming process in its broadest sense while providing the trainer and educator with every opportunity to apply the latest instructional techniques in the learning environment under complete scientific control.

CHAPTER III

THE SYSTEMS APPROACH - ITS DEVELOPMENT AND APPLICATION

Introduction

The development of Programmed Learning as a product and as a process traced in the previous chapter, received much of its impetus from extensive military research and application. Military organizations conducted much of the applied research that led to these techniques and have actively promoted their use.[1] The reason for this interest in Programmed Learning as a training strategy in the military would appear to lie in the approach they have taken over the past two decades with regard to the development of the complex equipment required and the training of personnel to man and maintain it. The discipline which deals with this complex man-machine relationship is Human Engineering. The connection between Human Engineering and Programmed Learning is worthy of study for it provides insight into the development of an approach which claims to possess characteristics and provide techniques which, if applied, are expected to have a profound effect on all facets of education and training.

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[1]Gordon A. Eckstrand, Current Status of the Technology of Training, Technical Report AMRL-TR-64-86 prepared for Behavioral Sciences Laboratory, (Aerospace) Medical Division Air Force Systems Command, Wright-Patterson Air Force Base, Ohio (September, 1964), p. 12.

Chapter III traces this development and examines the nature of the resultant new approach with a view to its practical application to existing educational and training structures.

Human Engineering and the Systems Approach

Human Engineering has been defined as follows:

> The term human engineering means engineering equipment for human use - not engineering the human . . . ."Good" human engineering means that the designer has made optimum use of both man and machine capability. This human engineering is concerned with assigning to each-man and machine - the functions each performs best, but always considering that man-machine operate as an integral unit.[2]

It is interesting to note that Human Engineering has not always taken such a sophisticated approach. In the 1920's, studies were carried out primarily in the field of the design of dials, placement of controls and special colour coding for single pieces of equipment to improve operator efficiency. In the 1930's, the emphasis shifted to optimizing psychomotor skills and sensory capacities. It was not until the mid 40's, however, that Human Engineering began to consider man as a link or component in systems. This new concept of the human arose from the growing need to examine entire systems - not just components. From the mid-1950's to the present time, this trend has developed into systems research which deals with the principles governing the behavior of systems.[3] The Systems Approach to complete man-machine

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[2]Sylvia R. Mayer, Human Engineering in the Design of Instructional Systems, Technical Documentary Report No. ESD-TDR-64-454 prepared for Decision Sciences Laboratory, Air Force Systems Command, United States Air Force (Washington: U.S. Department of Commerce, 1964), p. 2.

[3]Ibid., p. 3.

designs has become a reality.

To comprehend the nature of the Systems Approach, it is necessary that the meaning of the term system be clear. Stolurow provides the following definition.

> A system is a set of objects which is united by some form of regular interaction or inter-dependence. A change in a system is regarded as a change in the properties of the objects or in the relationships between the objects. Each object is considered as possessing certain properties of interest which may be used to define it.[4]

With this definition in mind, the design and/or modification of any system in the interest of attainment of system objectives requires a careful study of the properties of the elements, the element interface characteristics, and the interaction and inter-dependence of the elements. Concern for this requirement was expressed by Kopstein and Morgan in an early report on the subject:

> It is well known that human beings are an integral part of most weapon systems. Also, it is true that the design of efficient systems requires consideration of the functions and inter-actions of all components and sub-systems. System performance is dependent on the performance of each component or sub-system, and care must be taken not to exceed the limits of any component.[5]

Within the discipline of Human Engineering, these problems are viewed and solved by employing the System

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[4]Lawrence M. Stolurow, Systems Approach to Instruction, Technical Report No. 7 prepared for Office of Naval Research under Contract Nonr. 3985(04) (Washington: U.S. Department of Commerce, 1965), p. 1.

[5]Felix F. Kopstein and Ross L. Morgan, Human Factors Considerations in the Design Proposals for a Ballistic Missile Unit Proficiency System, Technical Note WADC 57-352 Prepared for Aero Medical Laboratory, Wright Air Development Centre, Wright-Patterson Air Force Base, Ohio (Washington: U.S. Department of Commerce, 1957), p. 1.

Approach which Stolurow defines as a technique which:

> . . . takes an executive orientation to problems since it assumes behaviour of any part of the system ultimately has some effect on every other part; the search is for significant interactions between, or among, the parts. The approach is the opposite of the more conventional procedure of "cutting a problem down to size." It enlarges the problem to include its interactions, deals with the more complicated problems, and applies new methods of investigation to them.[6]

As indicated previously, Human Engineering in its early stages stressed the need to design equipment suited to the man and thus concentrated their studies on man's capabilities. The Systems Approach does not deny this early work but rather indicates the need now for a more balanced study of all the elements of the man-machine system in the interest of achieving system objectives in the most efficient manner.

Kidd provides a very lucid explanation of what this approach implies in its broadest sense.

> The "systems concept" has already been tested in application in several important ways. The close relationship between the design of machines and systems on the one hand, and the development of effective personnel sub-systems, the establishment of training programs, and the maintenance of human skills, on the other hand, is now recognized and acted upon in industry and in the military. Also it has become apparent that there are basic analogies between the dynamics of men with other men and of men with machine components, not only from the viewpoint of productivity, but also with respect to motivation and job satisfaction. The systems concept thus tends to include all pertinent aspects of information exchange between system elements, and system research involves many non-mechanistic variables.[7]

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[6] Stolurow, op. cit.

[7] J. S. Kidd, A Summary of Research Methods Operation Characteristics, and System Design Specifications Based on the Study of a Simulated Radar Air Traffic Control System, a Technical Report WADC 59-236 Prepared for Aero Medical Laboratory, Wright Air Development Centre, Wright-Patterson Air Force Base, Ohio (Washington: U.S. Department of Commerce, 1959), pp. 1-2.

The Systems Approach and Programmed Learning

Figure 25 illustrates the element interrelationships in two analogous designs as the human and non-human elements of each interact. It is significant that while Human Engineering has been developing techniques to ensure optimum assignment of element functions and to investigate the nature of element interfaces in complex man-machine designs (figure 25(a)), Programmed Learning, as described in Chapter 2, has been developing a product and a process which appear to be equally concerned with element function allocations and interface problems in complex educational/training designs. (Figure 25(b)).

A review of Skinner's point of view on human learning and two of the characteristics of the Skinner programme will serve to illustrate this concern. Student learning is the prime objective of the educational/training design and Skinner proposed operant conditioning as the process by which the objective could be achieved most successfully. Implementation of this process was based on a knowledge of the learning characteristics of one of the elements of the design - the learner. Skinner's extensive research in conditioning of organisms well down the phylogenetic scale led him to make strong inferences with respect to human learning. His eventual application of the reinforcement principle within the structure of the linear program can be viewed as an engineered solution to an interface problem between the student/learner and the new behavior to be acquired

ELEMENT INTERRELATIONSHIPS

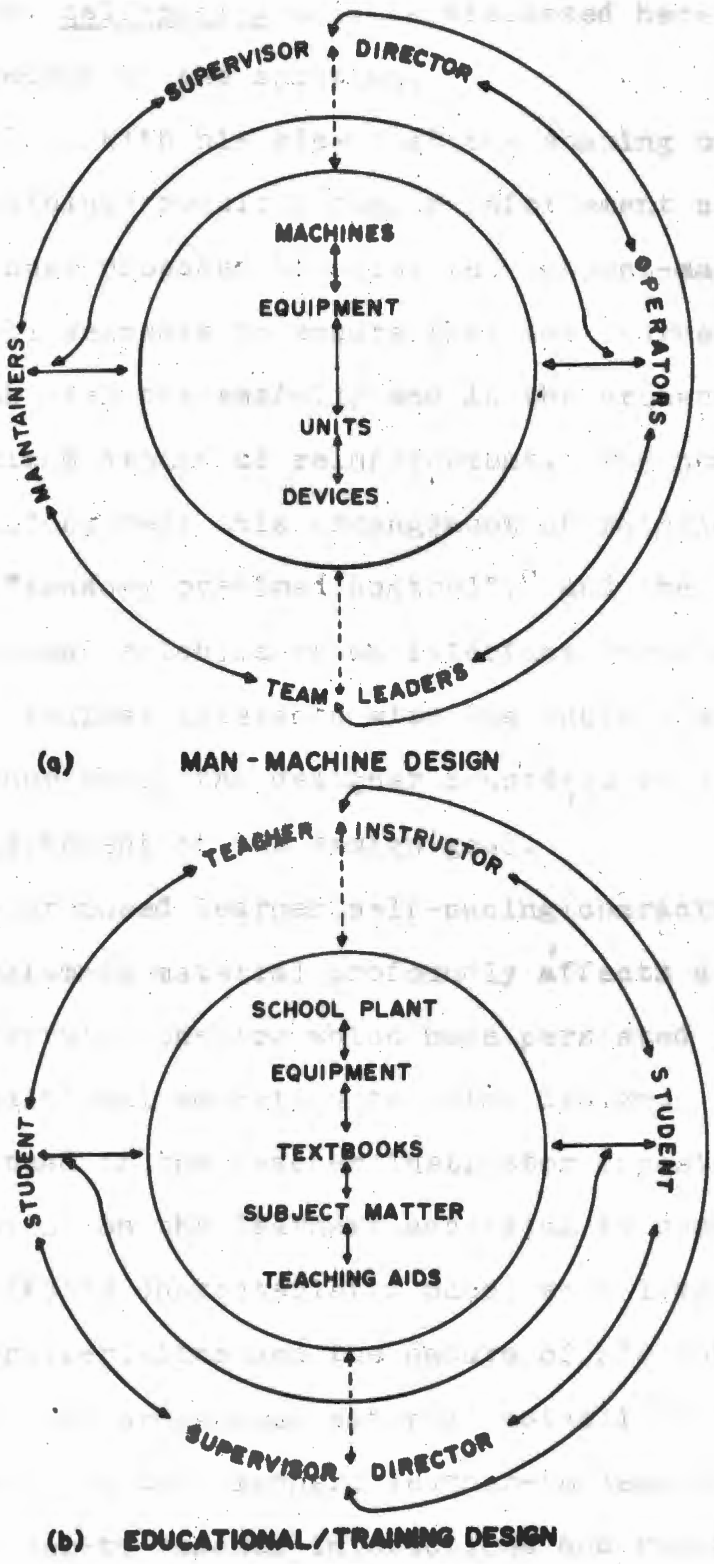

Figure 25

in terms of the subject matter to be learned. Small-step structure and self-pacing will be discussed here as representative facets of the solution.

1) In line with his view that the shaping of behavior (learning) required many reinforcement contingencies, Skinner proposed breaking the subject-matter into very small segments to ensure that the learner could handle each step successfully and in the process receive the maximum amount of reinforcement. The human engineer would express this arrangement of material in terms of "sensory overload control",[8] and the small-step proposal establishes an interface structure whereby the learner interacts with the subject matter in a manner which the designer considers will ensure achievement of the design goal.

2) The proposed learner self-pacing characteristic of programmed material profoundly affects a number of interrelationships which have persisted in the traditional education/training design.
Instead of the teacher/instructor imposing pace control on the learners according to some "average" student's characteristic pace, each learner's own characteristics and the nature of his interaction with the programmed material establishes the learning pace. In this manner, learner-to-learner and learner-to-teacher interactions and relationships

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[8] Mayer, op. cit., p. 6.

undergo a radical re-alignment in the programmed learning design as Skinner envisaged it. Also the function of the teacher (or conventional textbook, notes on blackboard, etc.), as a disseminator of information, has shifted to the programme.

This shift of function and change of interface characteristics has, in certain situations, caused the instructional program to replace all or part of the teacher's function with respect to learning pace control and provision of reinforcement contingencies. Skinner considered that the instructional programme, with or without a machine, could do a better job of it than a teacher/instructor in a conventional classroom with 20-30 learners.

Further insight into this concept can be achieved by consideration of a simplified example in a man-machine design. As the launching ranges of offensive weapons began to exceed the human-optical visual capability, electronic tracking systems were designed to replace the more conventional manual optical tracking devices. In such systems, the human tracking function was replaced by "hardware" even though it was shown that the human being could optically track more accurately and more smoothly <u>as long as he could see the target</u>. In this example, the critical requirement to achieve the system objective - the protection of one's forces at extended ranges - overcame any humanistic argument. It is worthy of note, however, that the human operator is still employed in making those judgements for which is admirably suited and which the hardware cannot as yet handle. The hardware is used to extend the human capabilities, leaving the human operator to tend to those functions he performs best. It would appear that Skinner's viewpoint, with respect to the rightful function of the teacher, was in the same context when he stated:

> If the advances which have recently been made in our control of behaviour can give the child a genuine competence in reading, writing, spelling and arithmetic, then the teacher may begin to function, not in lieu of a cheap machine, but through intellectual, cultural, and emotional contact of that distinctive sort which testify to her status as a human being.[9]

From this limited comparison of the application of Human Engineering to the man-machine design and the application of Programmed Learning to the education/training design it is possible to suggest why the military and industry, in particular, have taken such an interest in Skinner's (and Crowder's) proposals. They had already observed the fulfilment of the promise Human Engineering had proposed in solving problems in the complex man-machine design. Programmed Learning with its behavioural objectives, careful behavioural analysis and validation in terms of achieved measurable behavioural changes in the learner, appeared to hold out similar promise in solving problems in the educational/training design. Seemingly, all that remained was to develop the programming process in the manner in which Human Engineering had developed. Mayer expressed it as follows:

> The problems now confronting instructional system designers strongly resemble those that psychologists have been facing in the human engineering of non-

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[9]B. F. Skinner, "The Science of Learning and the Art of Teaching", Harvard Educational Review XXIV (Spring, 1954), 112.

> instructional systems. In fact, programmed instruction's prime tool-subject-matter analysis and definition of terminal objectives - is an outgrowth of the human engineers' task analysis methodology.... Perhaps the elusive instructional concepts of "step size", "frame," "response type," "programming style" might prove more amenable to analysis and measurement if they were re-examined in the light of the human engineer's concepts and tools.[10]

The structure of the System Approach as applied by human engineers to complex man-machine systems is illustrated by a diagram from Gagné[11]. (Figure 26). Attention is directed to the order in which the system objectives are established to meet the stated requirements of the system and the manner in which the respective functions of man and machine are carefully delineated early in the planning stage. Development of man and machine to perform their designated functions is carried out in parallel with a "bringing together" of the elements for the trial and validation steps prior to operational use of the system. The sub-system dealing with the development of personnel to perform their designated functions is of prime interest to this thesis. Corrigan[12] has adapted Gagné's man-machine system model to produce the educational/training system model illustrated in figure 27. In this model the interactions between instr-

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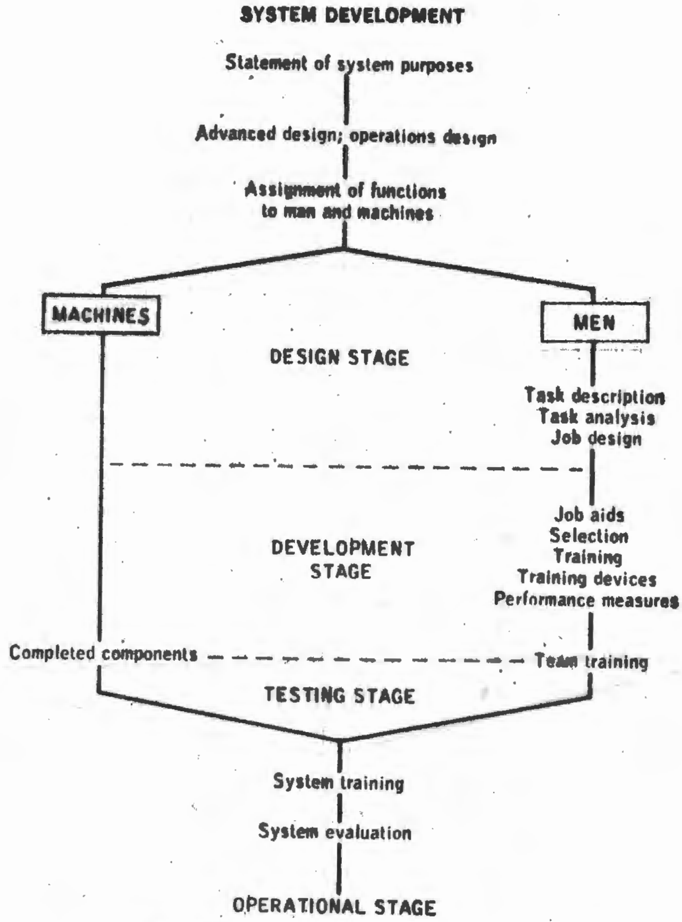
[10]Mayer, op. cit., p. 1.

[11]Robert M. Gagné (ed.), Psychological Principles in System Development (New York: Holt, Rinehart and Winston, 1963), p. 4. Figure 26 has been reproduced from this reference with the author's permission.

[12]Robert E. Corrigan, "Programmed Instruction as a System Approach to Education", in Trends in Programmed Instruction edited by Gabriel D. Ofiesh and Wesley C. Meierhenry, (Washington: Department of Audiovisual Instruction, National Education Association, 1964), p. 37.



The procedures used in the development of human components of systems, and their order of initiation, in relation to the stages of system development. Procedures used for equipment development are not shown in detail.

Figure 26.

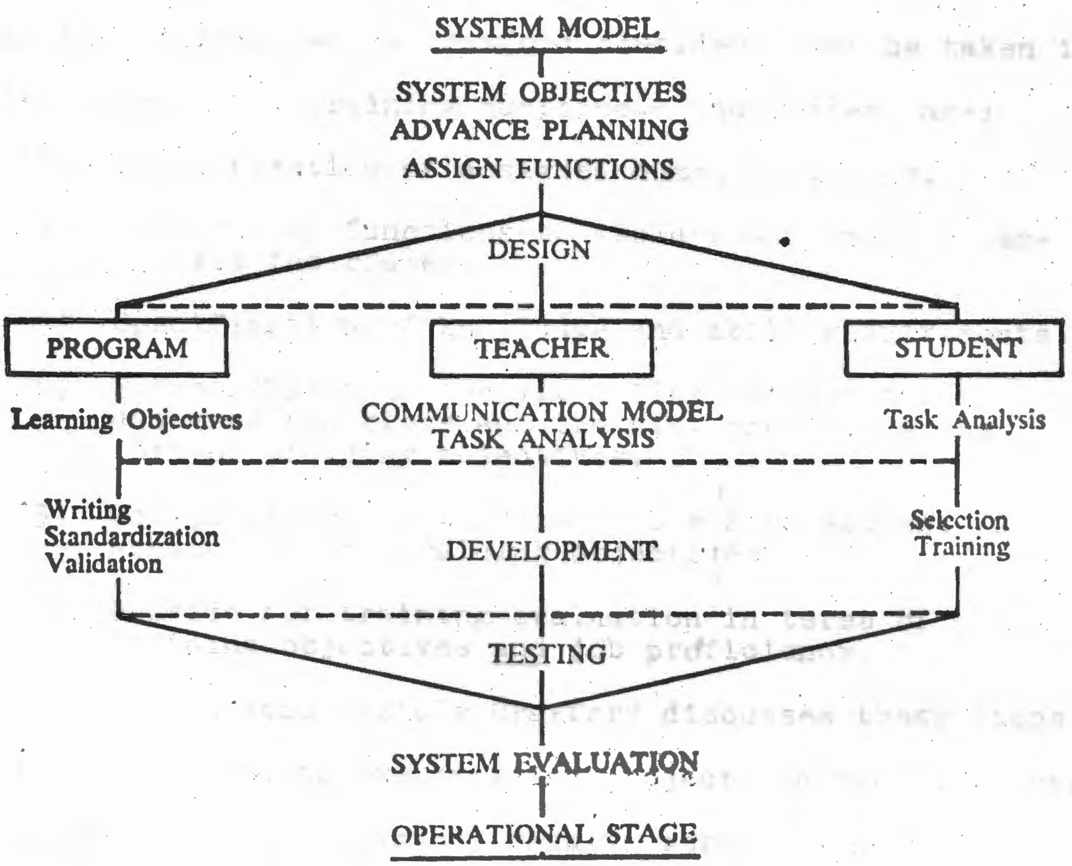


Fig. 27.--**Programmed Instruction as a Systems Model**

uctional programme, teacher and student are suggested and the processes to be implemented are related to each of the three principal elements.

Crawford describes the development of the personnel sub-system which must be established for the training of the human elements of the present man-machine system. Figure 28 depicts the steps which Crawford considers must be taken in system design for training purposes. These steps are:

1) Identification of assigned human functions.

2) Analysis of functions to isolate and examine man-machine interfaces.

3) Specification of knowledge and skill requirements.

4) Establishment of the vital link between the assigned functions and training process in the form of training objectives.

5) Design of training process to ensure student achievement of training objectives.

6) Provide for training evaluation in terms of training objectives <u>and</u> job proficiency.

In the same article Crawford discusses these steps as they were applied to two training projects in the U.S. Army where extremely satisfactory results were attained.[13]

The similarity between Crawford's process and the instructional programming production sequences illustrated in Figures 21 and 22 in Chapter 2 supports the view that the Systems Approach, as developed within the man-machine complexes,

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[13]Meredith P. Crawford, "Concepts of Training" in Psychological Principles in Systems Development edited by R. M. Gagné (New York: Holt, Rinehart and Winston, 1963), p. 328. Figure 28 has been reproduced from this reference with the editor's permission.

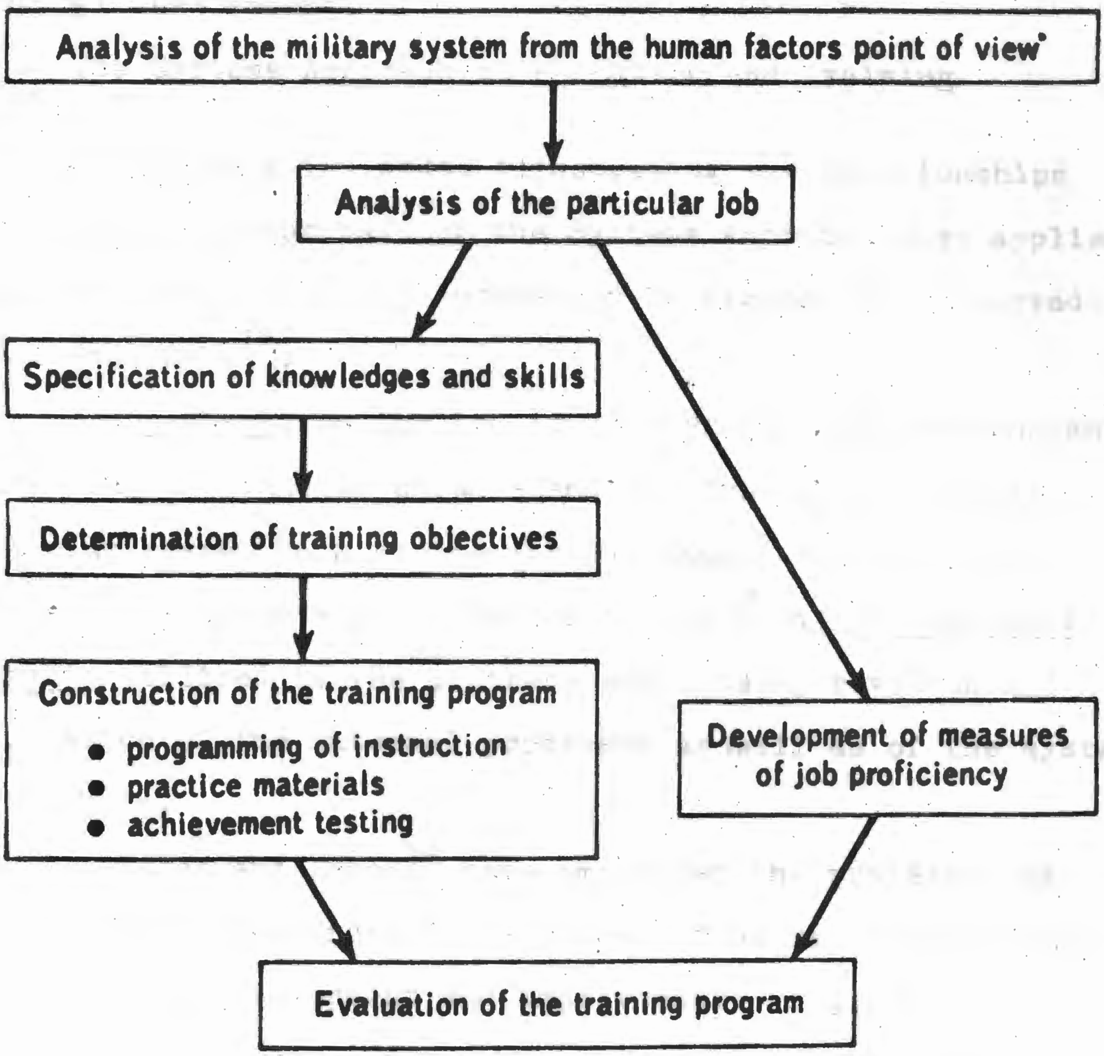

Fig. 28.--Steps in the development of training.

has been applied already within the training/educational environment in the specific development of Programmed Learning. From this point, the application of the Systems Concept in the broadest sense to the training/education complex is a natural development.

The Systems Approach to Education and Training

A simplified model illustrating the relationships between the sub-process of the Systems Approach when applied to a training complex is presented in Figure 29. (Adopted from Eckstrand[14]).

Feedback, as implied in both Programmed Learning and Human Engineering, is shown emanating from the output of the training system back to the various stages of the system. It is the element which provides the critical knowledge of results utilized in the ultimate evaluation, revision and validation of the internal processes as well as of the system as a whole.

Mager and Beach[15] have amplified the processes by dealing with them under three phases of course development - preparation, development and improvement. Figure 30 identifies the procedures which must be carried out if the Systems Approach is to be implemented. Note that the critical elements of job/task analysis, training objectives, course design and

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[14]Eckstrand, op. cit., p. 3.

[15]Robert F. Mager and Kenneth M. Beach, Jr., Developing Vocational Instruction (Palo Alto, California: Fearon Publishers, 1967), pp. 3-6. Figure 30 is a composite of four figures from the cited text.

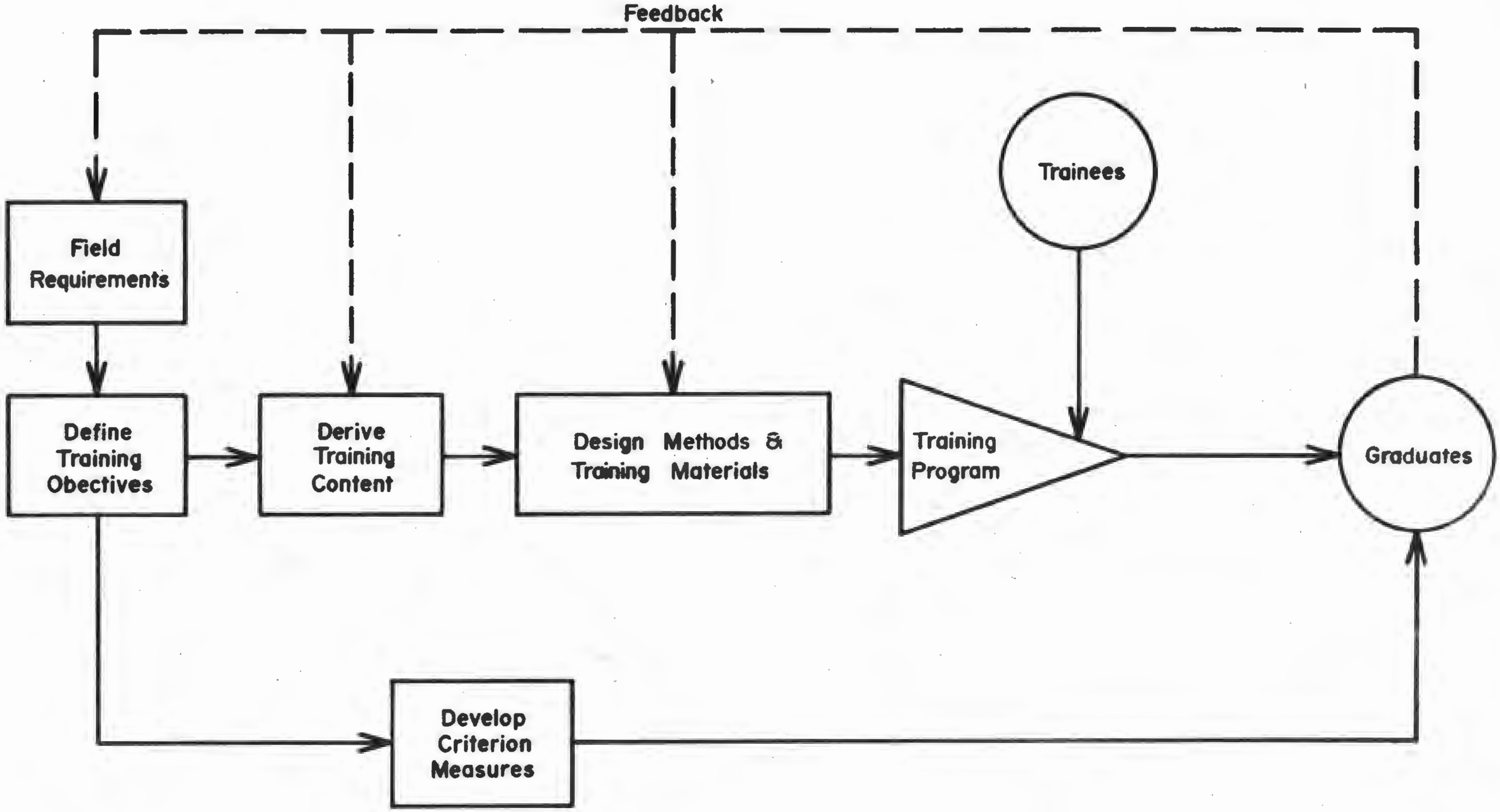

Fig. 29.--A SYSTEMS APPROACH TO TRAINING

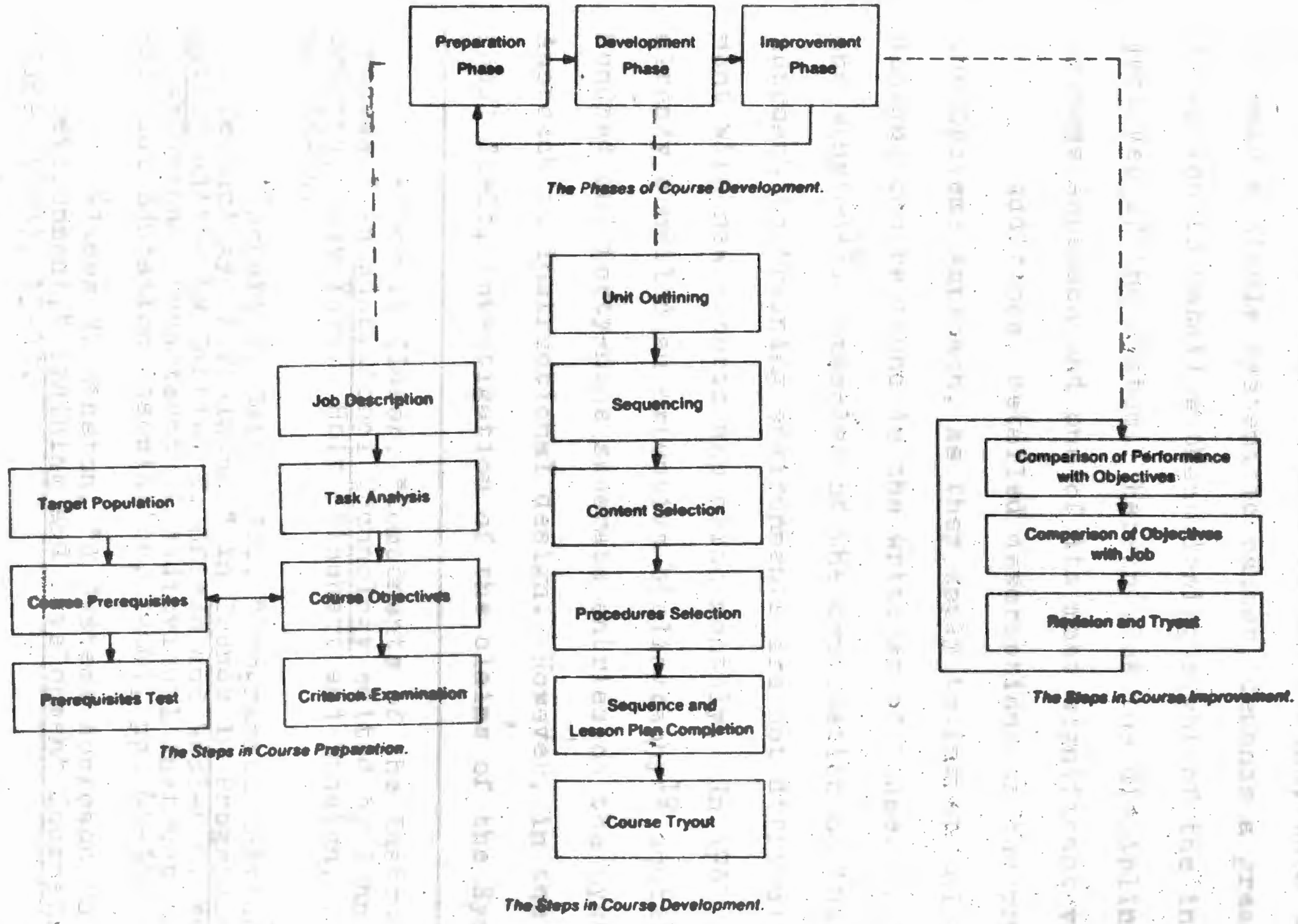

Fig. 30.--The phases of course development

validation in terms of achieved objectives, are well represented. From this presentation by Mager and Beach, it is clear that training and educational design, when approached in such a highly systematic manner, demands a great deal of attention to detail without losing sight of the initial objectives of the system. Herein lies the discipline of the Systems Approach and one of its most significant virtues.

Additional detailed descriptions of the processes of the Systems Approach, as they apply to industrial training design, can be found in the writings of Glaser[16], Smith[17], and Winston[18]. Examples of the application of the Systems Approach to training environments are not difficult to document with new reports appearing monthly. In 1967 Smith had already compiled an extensive bibliography[19] containing four hundred and forty-nine separate entries on the Systems Approach to instructional design. However, in the educational field, investigation of the claims of the Systems

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[16]Robert Glaser, "Components of the Instructional Process," in Educational Technology edited by John P. DeCecco, (New York: Holt, Rinehart and Winston, 1964), pp. 68-76.

[17]Robert G. Smith, Jr., "Programmed Instruction and the Technology of Training," in Trends in Programmed Instruction edited by Gabriel D. Ofiesh and Wesley C. Meierhenry (Washington: Department of Audiovisual Instruction and National Education Association, 1964), pp. 46-50.

[18]James S. Winston, "A Systems Approach to Training and Development," Training and Development Journal, XXII (June, 1968), 13-20.

[19]Robert G. Smith, Jr., An Annotated Bibliography on the Design of Instructional Systems, Technical Report 67-5 prepared for Office, Chief of Research and Development, Department of the Army (Alexandria, Virginia; The George Washington University, 1967).

Approach has been relatively slow to start. Two significant developments have been reported recently by Lehmann[20] on the ARISTOTLE project and by Flanagan[21] in his article on project PLAN. Both projects are actively investigating the application of the Systems Approach to educational systems. While it is not possible to describe these two ongoing projects here, suffice it to say that both incorporate the critical elements of the Systems Approach as represented in this thesis. Figure 31[22], which lists the critical steps of the educational systems cycle under investigation in the ARISTOTLE project, is included here for comparison purposes.

The structure of the Systems Approach with its required process has been outlined. While variations in practice may be reported, the following five processes appear to be common to all:

1) Determination of field/real world requirements and needs.

2) Establishment of training/educational objectives in terms of student achievement.

3) Careful development of the training/educational procedures to ensure student achievement of objectives.

4) Validation of system parameters in terms of student achievement of stated objectives.

5) Evaluation of the system in terms of graduate achievement in the field/real world.

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20 Henry Lehmann, "The Systems Approach to Education," <u>Audiovisual Instruction</u>, XIII (February, 1968), 144-148.

21 John C. Flanagan, "Functional Education for the Seventies," <u>Phi Delta Kappan</u>, (September, 1967), 27-32.

22 Lehmann, <u>op. cit</u>., p. 145.

THE EIGHT STEPS OF THE EDUCATIONAL SYSTEMS CYCLE

1. State the real NEED you are trying to satisfy.
2. Define the educational OBJECTIVES which will contribute to satisfying the real need.
3. Define those real world limiting CONSTRAINTS which any proposed system must satisfy.
4. Generate many different ALTERNATIVE systems.
5. SELECT the best alternative(s) by careful analysis.
6. IMPLEMENT the selected alternative(s) for testing.
7. Perform a thorough EVALUATION of the experimental system.
8. Based on experimental and real world results. FEEDBACK the required MODIFICATIONS and continue this cycle until the objectives have been attained.

Figure 31.

In order that the nature of these processes may be clarified and the promise they hold for improved educational/ training design may be properly represented, further detail on job/task analysis, objectives and their development, course design and the validation process follows.

Job/Task Analysis:

Job/Task analysis has been defined as:

> . . . the determination of what a person does, how he does it, why he does it and the skills involved in doing the work.[23]

Latterner adds that:

> . . . unless we know what the person is required to do, how he is to do it, why he does it and the skills (mental and physical) involved in doing the job, we cannot hope to be successful in training him.[24]

Morsh, who has been involved in job and task analysis with the U.S. Air Force for many years, suggests that systematically derived information about the jobs to which the learner will graduate can be used to ensure the relevancy of the training and " . . . the old attitude that there is 'a school taught way' to do a job and 'a real way' is eliminated. The school way guided by effective job analysis becomes the real way."[25]

Gagné's assessment of the value of job/task anal-

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[23]Charles Latterner, "Task Analysis - Bane or Blessing," in Trends in Programmed Instruction, op. cit., p. 166.

[24]Ibid.

[25]Joseph E. Morsh, "Job Analysis and its Application to Training," in Trends in Programmed Instruction, op. cit., p. 171.

ysis and the information which should be derived adds to the picture. He states:

> Here are the psychological principles that seem to be useful in training: (1) Any human task may be analyzed into a set of component tasks which are quite distinct from each other in terms of the experimental operations needed to produce them: (2) These tasks are mediators of the final task performance . . . .; (3) The basic principles of training design consist of: (a) identifying the component tasks of a final performance; (b) insuring that each of these component tasks is fully achieved; and (c) arranging the total learning situation in a sequence which will insure optional mediational effects from one component to another.[26]

Gagné further states that the traditional principles of learning such as reinforcement, differentiation of task elements, familiarity and distribution of practice are much less important in training than the principles of task analysis, intra-task transfer, component task achievement, and task sequencing.[27]

The methods of job/task analysis vary with the type of jobs being analyzed (man-ascendant or machine-ascendant) and with the purpose for which the analysis is being prepared (personnel selection, placement, job evaluation, methods of improvement, and others, including training). While it is impossible here to deal even with any one in detail,

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[26]Robert M. Gagné, "Presidential Address," Division of Military Psychology of the American Psychological Association, cited by Robert G. Smith, Jr., "Programmed Instruction and the Technology of Training," in <u>Trends in Programmed Instruction</u>, <u>ibid</u>., p. 46.

[27]Robert M. Gagné, "The Acquisition of Knowledge," <u>Psychological Review</u>, LXIX (1962), 355-365.

McGehee and Thayer[28] have suggested that whatever method may be adopted, the following data must be obtained for training purposes:

1) Standard of performance for the task or job.

2) If a task cluster or "job", the identification of the tasks which make up the job.

3) How each task is to be performed if standards of performance are to be met.

4) The skills, knowledge, and attitudes which are basic to the performance of each task in the required manner.

Mager and Beach[29] provide a process by which such data may be obtained. It requires that the following steps be taken:

1) List all the tasks that might be included in the job.

2) Assess frequency of performance, relative importance to the job, and relative learning difficulty. (See Figure 32).

3) List the steps involved in each of the tasks in terms of what the person does when performing the step.

4) Assess the type of performance involved and learning difficulty of each step of each task. (See Figure 33).

Mager and Beach comment further on the process as follows:

> While this may seem to be going into unnecessary detail, it must be stressed that these steps are essential in making intelligent choices of teaching techniques. With the task steps identified in this detail, we can better avoid the teaching trap of

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[28] William McGehee and Paul W. Thayer, Training in Business and Industry (New York: John Wiley and Sons, Inc., 1961), p. 64.

[29] Mager and Beach, *op. cit.*, p. 20.

TASK LISTING SHEET

Vocation: Electronics Technician

No.	Task	Frequency of Performance	Importance	Learning Difficulty
1.	Troubleshoots and repairs malfunctioning equipment.	Everyday occurrence	1	Difficult
2.	Reads electronic schematics.	1 to 10 times a day	2	Moderate
3.	Performs chassis layouts.	Once a week	2	Easy
4.	Uses small hand tools.	Continuously	1	Easy
5.	Checks electronic components.	Frequently	1	Moderate to very difficult
6.	Replaces components.	Once in a while	2	Easy to moderate
7.	Solders various components.	Frequently	2	Moderate
8.	Recognizes the applicability of electronic test equipment.	Once in a while	2	Difficult
9.	Interprets test instruments.	Frequently	1	Difficult
10.	Performs calibration of test equipment.	Once a month	3	Difficult
11.	Interprets and records test data.	Once in a while	3	Easy to moderate
12.	Specifies and orders electronic components.	Frequently	3	Easy
13.	Applies first aid procedures.	Very rarely	1	Moderate
14.	Maintains and cleans work areas.	Frequently	2	Easy

Figure 32.

TASK DETAILING SHEET

Vocation: Service Station Mechanic-attendant

***Task:* Clean and replace spark plugs**

No.	*Steps in Performing the Task*	*Type of Performance*	*Learning Difficulty*
1.	Note the plug location relative to the cylinder.	Recall	Easy
2.	Remove all spark plugs.	Manipulation	Easy
3.	Identify the type of plugs.	Discrimination	✓
4.	Decide whether to adjust or replace plugs.	Problem-solving	Moderately difficult
5.	Clean plugs, if necessary.	Manipulation	✓
6.	Adjust plugs, if appropriate.	Manipulation	Moderately difficult
7.	Replace spark plugs in engine.	Manipulation	✓
8.	Connect ignition wires to appropriate plugs.	Recall, manipulation	Moderately difficult
9.	Check for performance.	Discrimination	Very difficult
10.	Clean tools and equipment.	Manipulation	✓
	Note that some of these steps cannot be seen directly, but that they are nonetheless important in completing the task.		

Figure 33.

including more theory than is necessary or desirable and keep the course performance oriented.[30]

The techniques described by Mager and Beach may not suit all situations. Further examples are provided for perusual. Figures 34 and 35 are taken from Shriver[31] (machine-ascendant). Figures 36, 37 and 38, which illustrate a very interesting breakdown of the duties of an instructor, have been extracted from an article by Cummings.[32] (man-ascendant). Two additional examples of analysis technique are provided on pages 204 to 218 of Appendix B (man-ascendant) and pages 237 to 246 of Appendix C. (Machine-ascendant).

It can be seen that the Systems Approach insists that unless the functions of the graduate in the parent system are clearly defined and understood by the designer of the training/educational sub-system, the resulting design will be unrealistic and while graduates may pass the course, they may fail to function adequately in the operational enviornment. The process of job/task analysis as briefly described here is an earnest attempt to indicate how the trainer can ensure relevancy.

While it is admitted that the educational sub-system differs from the training sub-system primarily in the degree

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[30] Ibid., p. 20.

[31] Edgar L. Shriver, Determining Training Requirements for Electronic System Maintenance, Technical Report 63, Task FORECAST I, for the Department of the Army (Alexandria, Va: Human Resources Research office, The George Washington University, 1960), pp. 44-47.

[32] Roy J. Cummings, "Removing Intuition from Course Development," Training and Development Journal XXII (January, 1968), 22-24.

TASK ANALYSIS OF MIMEOGRAPH MACHINE
(A.B. Dick No. 445)

The task is presented first in terms of a gross analysis and then in terms of a subtask analysis.

GROSS TASK ANALYSIS

Name of Task	Display or Cue	Critical Values	Response	Subtasks (By Number)
A. "Set Up" Before Run	Position of brake	Not in 9 o'clock position	Move to 9 o'clock position	12
	Recall of last inking	Copy light since last inking	Measure ink	17, 18
	Amount of ink on stick after measuring	Less than 1/2 inch	Add ink	19, 20
		More than 1/2 inch	Needn't add ink	20
	Width of paper to be used	Different than previous paper	Change rail and guide	7, 21, 23, 11
	Length of paper to be used	Different than previous paper	Change breaker bar	7, 22, 24, 11
	Weight of paper to be used	Different than previous paper (Normal weight equals 20 lb.) The normal control positions for 20 lb. are: (a) ~~Feed grip at second notch from top~~	Increase for less than 20 lb. paper	25
			Decrease for more than 20 lb. paper	26
		(b) Buckle at middle number	Increase for less than 20 lb. paper	29
			Decrease for more than 20 lb. paper	30
	Amount of paper in machine	Less than one inch	Add paper	7, 10, 11
	Proposed speed	Feed pressure at second ring for speeds up to 100 copies per minute	Increase for higher speeds	27
			Decrease for lower speeds	28
	Desired speed	Increase over previous run	Increase	32
		Decrease under previous run	Decrease	33

(Continued)

(Over)

Figure 34.

131-A

Name of Task	Display or Cue	Critical Values	Response	Subtasks (By Number)
B. "Set-Up" Before Each Different Stencil Run	Cover on cylinder or not	Cover on	Remove cover	9
		Cover off	Attach stencil	2
	Number on counter	Not correct	Set correct number	3
	Machine on or off	Off	Start	35
C. Any Time During Run	Print with respect to: (a) Top of page	Too close	Lower print	4, 12, 35
	(b) Side of page	Too close	Move from side	4, 13, 35
	(c) Horizontal of page	Diagonal	Straighten	4, 14, 35
	(a), (b) or (c)	Print off page	Use "ink up" procedure	4, 15, 35
	Lightness of print (a) Ink not previously distributed	Print too light	Distribute ink	4, 16, 35
	(b) Ink previously distributed	Print too light	Add ink	4, 19, 20, 35
	Speed of machine		Changes speed	32 or 33
	Amount of paper	Less than one inch	Add paper	4, 7, 10, 11, 35
	Dirt on paper (a) Sides	Office standards	Clean retainer pads	4, 31, 35
	(b) Center	Office standards	Clean feed roll	4, 34, 35
D. End of Each Different Copy	Counter bell rings		"End off" procedure	4, 5, 6, 7, 8, 9

ANALYSIS OF SUBTASKS
(Cue Elements Are Identical to Control Elements in Subtask)

Name of Subtask	Control	Control Action (Response)	Indication of Response Adequacy
1. Release Brake	Brake	Turn clockwise up	Brake stop in 9 o'clock position
2. Attaching Stencil	Wheel	Turn	Stencil head clamp available
	Stencil head clamp	Lift left end	Stencil head clamp loosens
	Release latch	Lift	Stencil head clamp loosens further
	Stencil head clamp (edge away from stencil)	Push down	Stencil head clamp comes open
	Stencil	Put under head clamp as far as it will go (face down)	Feels it is against "end" of clamp
	Stencil head clamp lever	Push down	Stencil secured and straight
	Stencil back	Pull backward	Torn off backing
	Stencil	Smooth around cylinder	No wrinkles on stencil
	Wheel	Turn counterclockwise (left hand)	End clamp up
	End clamp lever	Lift	End clamp opens
	Stencil	Push under clamp	Under clamps smoothly
	End clamp	Push	Holds stencil firmly
	End clamp lever	Push down	Clamp flush—stencil secured
	Wheel	Turn clockwise	"Stop here" matched, on cylinder and frame
3. Setting Counter	Recorder control knob	Lift up	Stops
	Counter	Set to appropriate number copies	Correct number
	Recorder control knob	Push down	
4. Stop	Feed control lever	Press down	Paper stops going through
	Motor switch	Turn to left	Machine stops
5. "Stop Here" Match	Wheel	Turn	"Stop here" matched
6. Remove Copy	Copy	Pick up and transfer (both hands)	Copy removed to table
7. Lower Feed Table	Feed table release knob	Push to left	Feed table goes down
8. Single Copy or File Folder	File folder or single copy	Push folder in above paper positioning plate	Stops against insides of machine
	Wheel	Turn	Folder out other side
	File folder	Remove from other side	

(Continued)

(Over)

Figure 35.

Name of Subtask	Control	Control Action (Response)	Indication of Response Adequacy
9. Removing Stencil or Cover	End clamp lever	Lift	Clamp open
	Stencil	Take from under clamp and hold up (left hand)	Stencil out
	Wheel	Turn clockwise	
	Head clamp lever	Lift (right hand)	
	Stencil	Pull from beneath clamp and place in file folder	
10. Adding Paper	Wheel	Turn	"Stop heres" matched
	Any Order		
	Quick set lever	Turn clockwise	Rails and retainers move away
	Retainer pads	Push into their housings (two)	Clicks into place
	Feed table release knob	Push to left	Table goes down
	1/2 pack paper	Fan paper and push up to paper positioning plate and register edges by slapping	Paper registered on each side and against plate
	Quick set lever	Turn to right	Paper against retainers
	Simultaneously		
	Paper	Push down paper (toward table top) between retainer pads	
	Retainer pad release pad	Push down (both sides)	Paper retains "bend"
11. Raise Feed Table	Feed table elevating knob	Turn counterclockwise	Top of pack above positioning plate below feed roll
	Feed table release knob	Push to right	Table stays up
12. Correction for Print Too Close to Top	Raise lower copy lever	Lift	Up from cylinder
	Cylinder	Move so pointer is farther from zero by the desired change in copy distance in the direction of the word indicating desired direction of print movement	
	Raise lower copy lever	Push down	Flush with cyclinder
13. Correction for Print Too Close to Side	Lateral cylinder control	Clockwise to move print to right; counterclockwise to move left	

Duties of the FAA Academy Instructor.

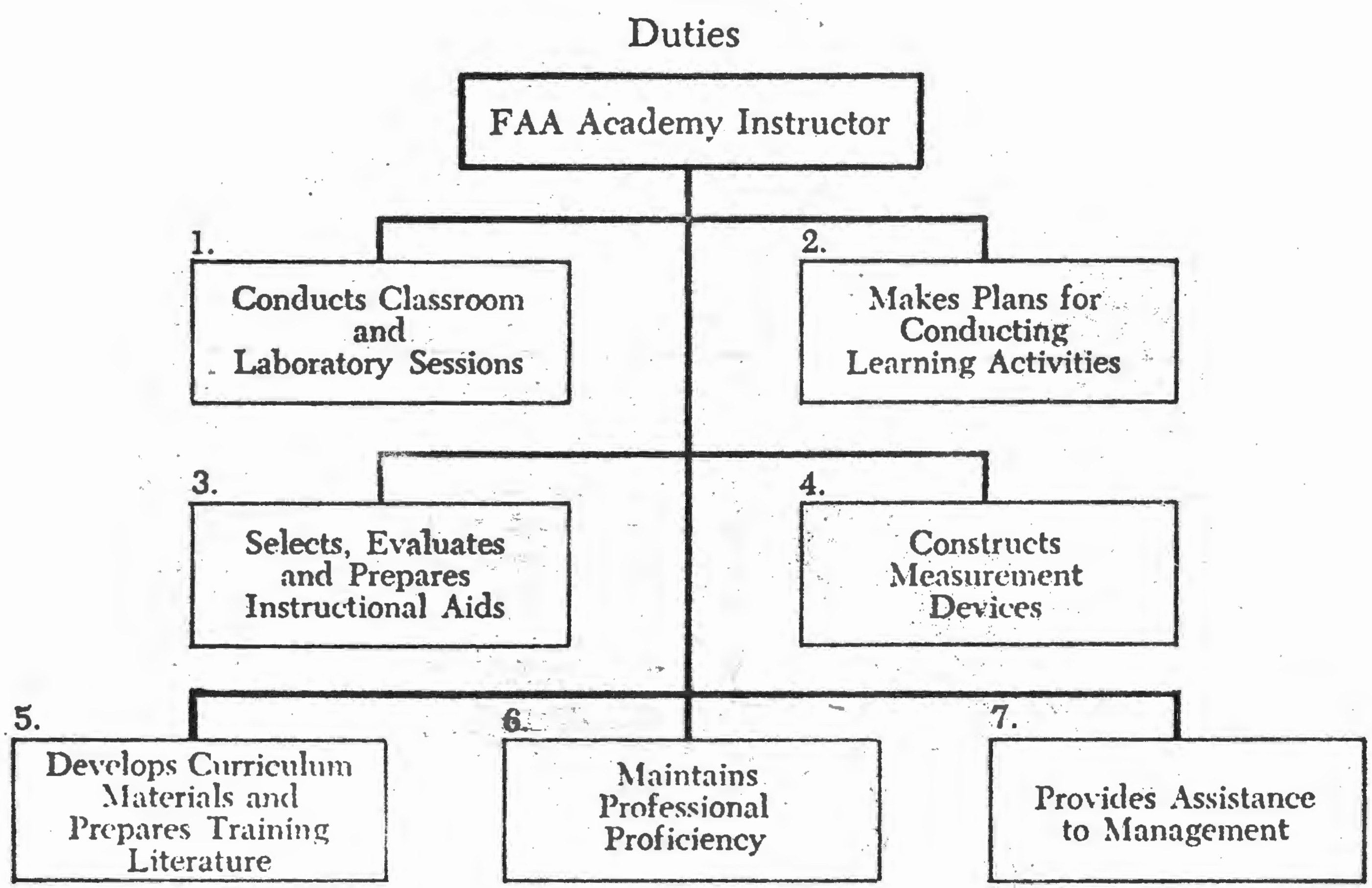

Figure 36.

Instructor Job/Task Analysis. Shows charting of task of conducting demonstrations.

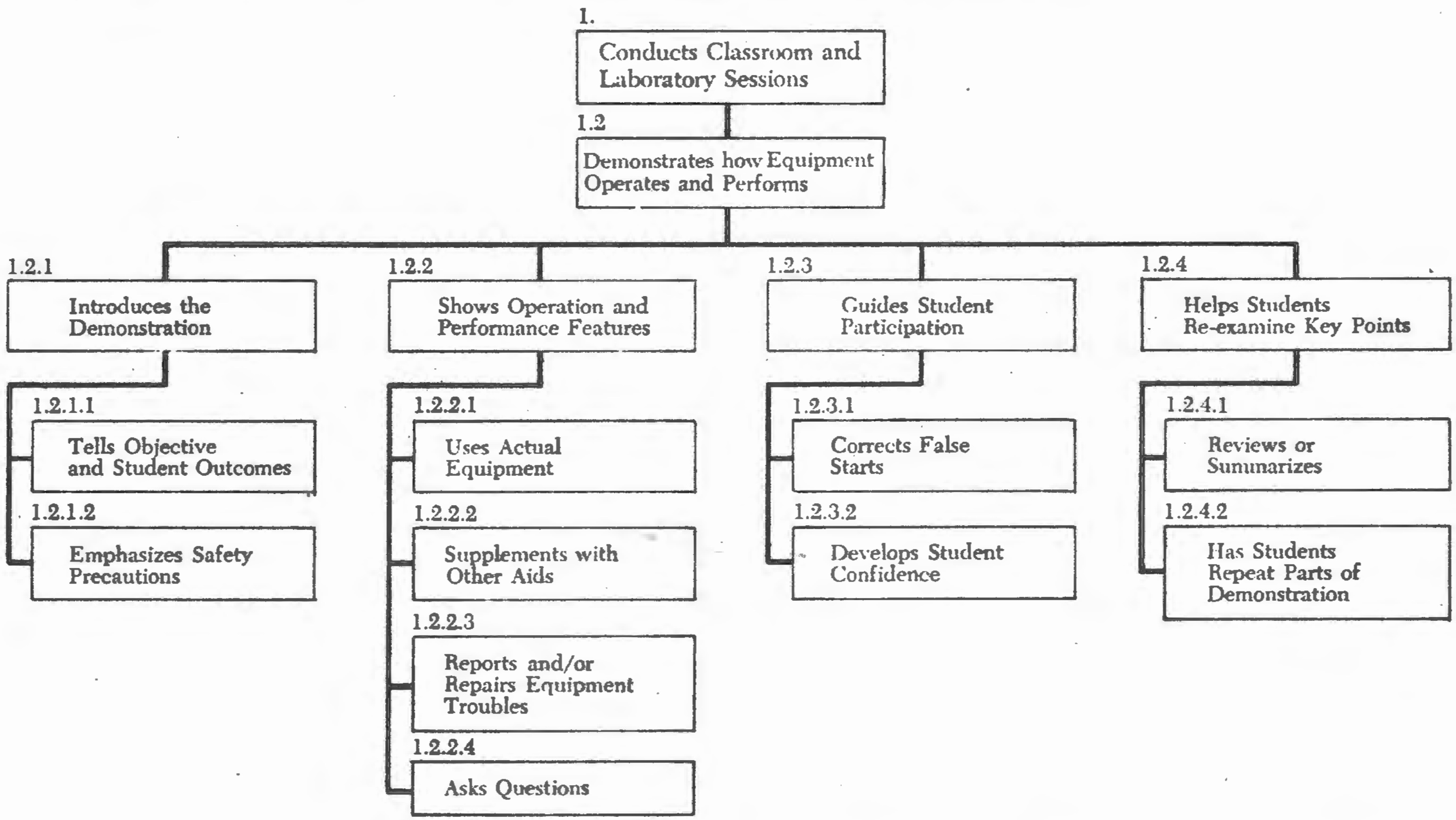

Figure 37.

Subordinate tasks to be accomplished by an instructor when conducting a demonstration.

FAA Academy Instructor

Duty: 1. Conducts Classroom and Laboratory Sessions

Task	*Sub-Task*	*Sub-Task Step*
1.2 Demonstrates how equipment operates and performs.	1.2.1 Introduces the demonstration.	1.2.1.1 Tells what is to be demonstrated and includes what the students will be able to do or know from having observed or taken part in the demonstration.
		1.2.1.2 Emphasizes initial safety precautions, if applicable, which will reduce or prevent damage to the equipment or personnel.
	1.2.2 Shows operational procedures of equipment and demonstrates how to handle malfunctions or problems.	1.2.2.1 Uses actual operational equipment when giving demonstrations.
		1.2.2.2 Supplements the demonstration by using simulators, cutaways, exploded views, transparencies, slides, film, tape recordings, charts, flannelgraphics, magnetics, handouts, schematics, miniatures, working models, and other items which will assist in the effectiveness of the demonstration.
		1.2.2.3 Reports equipment troubles to maintenance technicians or upon occasion repairs the equipment to clear the malfunction.
		1.2.2.4 Asks questions to determine student understanding.
	1.2.3 Guides students when they assist in presenting the demonstration.	1.2.3.1 Corrects false starts and errors.
		1.2.3.2 Assists students attain self confidence through their participation.
	1.2.4 Guides students to re-examine the key points of the demonstration so as to assure accomplishment of the lesson objectives.	1.2.4.1 Reviews or summarizes the operation and performance features of the equipment.
		1.2.4.2 Assigns students to repeat portions of the demonstration.

Figure 38.

of specificity of functions for which its graduates must be prepared, the Systems Approach still insists that a high degree of definition of the nature of the parent system - the social environment - is the only foundation upon which to build. For example, if the graduate's ability to function as a "good citizen" at any level of society, is a relevant parent system requirement, then the elements of that function (task?) must be defined. If this would seem impossible because of the many social circumstances which appear to need consideration, speculate for a moment on just what the teacher of citizenship will expect of her graduates as an indication of their proclivity towards good citizenship. How do we define a good citizen in our society? What judgements must our graduates make? Is the teacher to be involved in teaching concepts, attitudes, ability to discriminate and problem solve, or will the facts do? Only analysis of the requirements of the parent system - society - can provide the base upon which these questions can be answered satisfactorily. In the simpler societies of the past, the degree of irrelevancy of what was taught and learned under a teacher, who was considered to be a complete representative of society in her teaching, was not excessive. In the more complex society of today the teacher must resort to a combination of the curriculum and the textbook as a mirror of society. If these two are not adequate to the task, the teacher may well find herself teaching irrelevant material and the students will graduate with less-than-adequate abilities for the society in which they live. The solution for this problem cannot be found in random innovation on the part of the administrator or teacher. For this reason the System Approach insists on careful analysis of the requirements of the complex society as the basis of educational development. While the degree of specificity of such an analysis may be open to discussion, the need for analysis is not. As Blyth puts it, " . . . questions about the aims of education are philosophical. Questions concerning the most effective way to attain those aims are scientific."[33]

While this treatment of task analysis has been cursory, the intent was to outline the purpose of job/task analysis, the data to be obtained and the steps to be taken to obtain it. The attempt to identify the knowledge and skills to be attained by the student to prepare him for the tasks has been indicated. For a more comprehensive treatment of task analysis with a view toward the development of training objectives, the reader's attention is directed to Smith's research bulletin.[34]

Once the real-world/operational requirements have been classified by analysis, the establishment of a relevant learning environment is feasible. The critical link between these requirements and the learning environment is in the

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[33]John W. Blyth, "Programmed Instruction and the Philosophy of Education," in Trends in Programmed Instruction, op. cit., p. 14.

[34]Robert G. Smith, The Development of Training Objectives, Research Bulletin No. 11, prepared for the Department of the Army (Alexandria: Va., The Human Resources Research Office, The George Washington University, 1964), pp. 29-60.

educational/training objectives which are established in terms of expected student performance.

Educational/Training Objectives and Instructional Design

Objectives

> In a sense, a teacher makes a contract with his students. The students agree to pay a certain sum of money and effort in return for certain skills and knowledge. But most of the time they are expected to pay for something which is never carefully defined or described. They are asked to buy (with effort) a product which they are not allowed to see and which is only vaguely described. The teacher who doesn't clearly specify his instructional objectives, who doesn't describe to the best of his ability how he intends the learner to be different after his instruction, is certainly taking unfair advantage of his students.[35]

The above excerpt from Mager's well-known programmed booklet on the development of instructional objectives almost makes a moral issue of the all too common lack of clarification of intent on the part of the teacher. The need for objectives in the design of the educational/training sub-system goes even further than the critical interface between teacher and learner. The objectives also establish the link between the parent system requirement as defined by job/task/need analysis and the actual activities in the educational/training environment. Eckstrand establishes the part played by the sub-system objectives as follows:

> Based upon the specification of knowledges and skills which are required to meet job performance standards, the objectives of training are formulated . . . these objectives are essentially specifications

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[35]Robert F. Mager, Preparing Objectives for Programmed Instruction (San Francisco: Fearon Publishers, 1962), p. 17.

which define the out-put which is expected from the training system. The clarity and adequacy with which this can be accomplished is primarily dependent upon the completeness and accuracy of the determination of knowledge and skill requirement. A well formulated set of training objectives must meet at least the following general criteria:

1. Relevance - Is each training objective defensible in terms of the knowledge and skill required for adequate job performance?

2. Completeness - Do the objectives account for all of the required performance output?

3. Measurability - Are the objectives stated in a way which suggest an operation for determining that each objective has been achieved?[36]

While much has been written about the structure of training and educational objectives, no individual writer has provided as progressive an approach as Mager. In specifying the behaviour expected of the student following a period of learning, Mager[37] states that the teacher/instructor must:

a. Identify and name the over-all behaviour act.

b. Define the important condition under which the behaviour is to occur (given and/or restrictions and limitations).

c. Define the criterion of acceptable performance.

When developing behavioural objectives for course design, considerable judgement on the part of the educator/trainer is required with respect to the central position of the student in the learning environment, the specificity of the objectives and the relevancy of the desired behaviour

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[36]Eckstrand, op. cit., pp. 6-7.

[37]Mager, Preparing Objectives for Programmed Instruction, op. cit., p. 53.

objectives to coincide with the learning behaviours which would appear relevant to educational requirements. They also provide examples of test items which are designed to measure the various behaviours the objectives demand. It is worthy of note that behaviour patterns in the affective domain are most difficult to define and seemingly impossible to measure directly or accurately. Little attention has been given to objective development in this area in the existing literature in spite of the fact that it is equally important in both educational and training system design.

Dr. Albert F. Eiss, the Associate Executive Secretary of the National Science Teachers' Association, has been carrying out research in the development of educational objectives in the affective domain. Two of the problems he is studying in this area have to do with the types of objectives which will dependably describe overt behaviour which will statistically correlate with the covert attitudes of the students and the methods to be used to pre-and post-test attitudes in the attempt to measure behavioural change as an indication of attitude development or change.[40]

There seems to be little doubt from the foregoing short section that the development and use of objectives of the type described can provide the teacher/instructor in the classroom with a powerful communication tool. As Melching says:

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[40]Interview in Halifax, N.S., with Dr. Albert F. Eiss, Associate Executive Secretary, National Science Teachers' Association, U.S.A., July 18, 1968.

An example should clarify the nature of the process of objective development. Let it be assumed that junior officers are to be given initial training in leadership - a very necessary officer-like quality which must begin to be developed early in an officer's service career. It is recognized that the relatively short training period cannot hope to graduate leaders in the full sense of the word. What one would attempt to do would be to provide the officers with a realistic approach to the applications of leadership principles and the ability to see the need to develop leadership qualities within themselves. Figure 39 lists a number of hypothetical objectives which might be developed to achieve in part the requirement outlined above. Commentary is provided on the suitability of each objective in the light of the purpose and structure of objectives provided earlier in this section.

In recognition of the need to develop measurable behavioural objectives within educational as well as training systems, Bloom, Krathwall, et al, have developed comprehensive taxonomies of educational objectives in the cognitive[38] and affective[39] domains. While they do not profess to present real objectives relative to specific requirements of educational design, they do develop types of

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[38] Benjamin S. Bloom, et al. (eds.), Taxonomy of Educational Objectives - Handbook I: Cognitive Domain (New York: David McKay Company, Inc., 1964).

[39] David R. Krathwohl, Benjamin S. Bloom, and Bertrand B. Masia, Taxonomy of Educational Objectives - Handbook II: Affective Domain (New York: David McKay Company, Inc., 1964).

OBJECTIVE DEVELOPMENT

1. To teach the principles of leadership. (Teacher-oriented and vague).

2. The student will know the principles of leadership. (Student-oriented and vague).

3. The student will state the eight principles of leadership. (Student-oriented, specific, but highly suspect as the ultimate behaviour desired in the light of operational requirements. Would be suitable possibly as a sub-objective leading to higher level behaviour).

4. Without the use of references, the student will state the principles of leadership as listed in the text in two minutes. (Student-oriented, specific, highly suspect as ultimate behaviour desired and criteria does not seem relevant).

5. Given a number of situations, the student will select those which illustrate applications of leadership principles and will identify the particular principles applied in each selected situation. (Student required to be able to select 90% of the situations and identify 80% of the principles applied.) (Student oriented, specific, criteria could be important with this behaviour as a measure of developed skill. This objective considerably more task-relevant than 1-4 above.)

6. Given a number of service problems situations of the type the student is likely to encounter during first operational posting, student will select these problems which were due to lack of leadership on the part of the personnel involved, and state how the situation might have been avoided by the application of leadership principles. (Student-oriented, highly task relevant and specific.)

Fig. 39.--Objective development

> . . . instructional goals that are clearly communicated are more likely to be attained than goals that are not clearly communicated. In short, the premise is that when the instructional intent is clearly communicated, students are able to do a better job of learning. Put another way: when the student and the instructor know where they're going, both stand a better chance of getting there.[41]

The place of objectives in the training design can be summed up in the words of Crawford who states:

> The training course objective should be:
>
> 1. described from the job in terms of what is actually required for job performance;
> 2. arranged in hierarchiral order for the program as a whole and for each unit of instruction within the program;
> 3. cognizant of the knowledges and skills already within the repertory of students before the training begins;
> 4. reasonably within the achievement level of the student;
> 5. communicated to the student.[42]

In the endeavour to establish these critical instructional objectives, the oft-claimed difference between education and training tend to merge and a re-focussing occurs. The point being made at this stage in the Systems Approach is that, regardless of the degree of specificity of the overall real-world requirement, the meaningful activities in which the student is to become involved must be clearly identified and specified if, as a graduate, he

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[41] William M. Melching, et. al., Deriving, Specifying, and Using Instructional Objectives, Professional Paper 10-66 presented at 13th Annual Convention Southwestern Psychological Association, Arlington, Texas, April, 1966. (Alexandria, Va., Human Resources Research Office, The George Washington University, 1966), p. 1.

[42] Meredith P. Crawford, "Concepts of Training," in Psychological Principles in System Development, op. cit., p. 326.

is to benefit from his learning experiences.

For those who may wish to pursue the subject of education/training objectives further, a research memorandum by Hoehn and McClure[43] and an article by Mager[44] will provide valuable practical information. Smith's annotated bibliography[45] on objectives is an extremely useful source, and Appendix C of this thesis provides examples of Performance Objectives which were developed in a project being conducted within the Canadian Forces.

Instructional Design:

For the purpose of simplicity in most System Approach representations, the process of objective specification is shown to be a separate step from the process of course design. This is not realistic, however, because the objective "developer" must keep one eye on the parent system requirements and the other on the course design as he specifies the objectives. If he does not do this he runs the risk of having all of his objectives as merely restatements of the parent system requirements and some fail

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[43]Arthur J. Hoehn and Andrew H. McClure, The Development of Training Programs for First Enlistment Repairment: I. How to Define Training Objectives, A Research Memorandum prepared for the Department of the Army (Alexandria, Va: Human Resources Research Office, The George Washington University, 1960).

[44]Robert F. Mager, "Deriving Objectives for the High School Curriculum, "National Society for Programmed Instruction Journal VII (March, 1968), 7-14, 22.

[45]Robert G. Smith, Jr., An Annotated Bibliography on the Determination of Training Objectives, A Research Memorandum prepared for the Department of the Army (Washington: U.S. Department of Commerce, 1964).

to be meaningful or achievable within the learning environment, <u>or</u> specifying objectives in terms of subject-matter where they often become so miniscule as to approach irrelevancy as far as the parent system requirements are concerned. The ideal would seem to be to establish objectives representing student behaviours which approximate the parent system requirements as closely as the learning environment will permit.

Ralph Tyler has expressed the problem as follows:

> . . . the appropriate level of specificity of performance objectives is that of a meaningful unit of performance wherein the activity will be done for its own sake in the intended work situation. It should be stated at the level required for effective use in life, the performance of which can be valued in and of itself.
>
> Thus . . . "able to read French" is too general a statement to be called a meaningful unit of performance, while "able to read material in Paris newspaper" is closer to what is required for effective use in life. "Able to identify subjective mood" would represent a <u>means</u> to the objective, not an important objective in itself.[46]

It can be seen that student performance objectives can be stated at any one of the three levels indicated. The first represents a general aim but the second is the terminal performance which is meaningful. The third level objective is often designated as an "enabling objective"[47] which usually consist of one of a number of component actions, knowledges, or skills the student must learn if

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[46] Ralph W. Tyler, "Some Persistent Questions on the Defining of Objectives," in <u>Defining Educational Objectives</u>, edited by C. M. Lindvall cited by William H. Melching <u>et al</u>. <u>Deriving, Specifying and Using Instructional Objectives</u>, <u>op. cit</u>. p. 5.

[47] Melching, <u>et. al</u>., <u>ibid</u>., p. 6.

he is to attain the terminal objective.

This extension of the discussion of objectives into that of course design is necessitated by the fact the course itself will contain many sub-objectives or enabling objectives leading to terminal performance. The selection of these enabling objectives, sequencing of these and deciding on the teaching strategies to be employed in student development towards their attainment step-by-step is, in essence, course design.

A great deal has been written on how best to ensure achievement of the terminal objectives. It is not the intent here to deal in detail with the process suggested in these writings. However, the systems approach does indicate certain processes which should be carried out during this critical phase. To begin with it is considered that this design phase should be structured in a manner similar to the model of the parent system. Figure 40 provides a sample of the sequence of events to be followed, while Figure 41 taken from Smith[48] shows the relationships between the objectives, student activities and instructional requirements. However, the teacher/instructor must decide which instructional procedures to use and what media to select in order that the students may develop towards the objectives. Briggs suggests:

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[48]Robert G. Smith, Jr., The Design of Instructional Systems, Technical Report 66-18 prepared for the Department of the Army (Washington: U.S. Department of Commerce, 1966), p. 7.

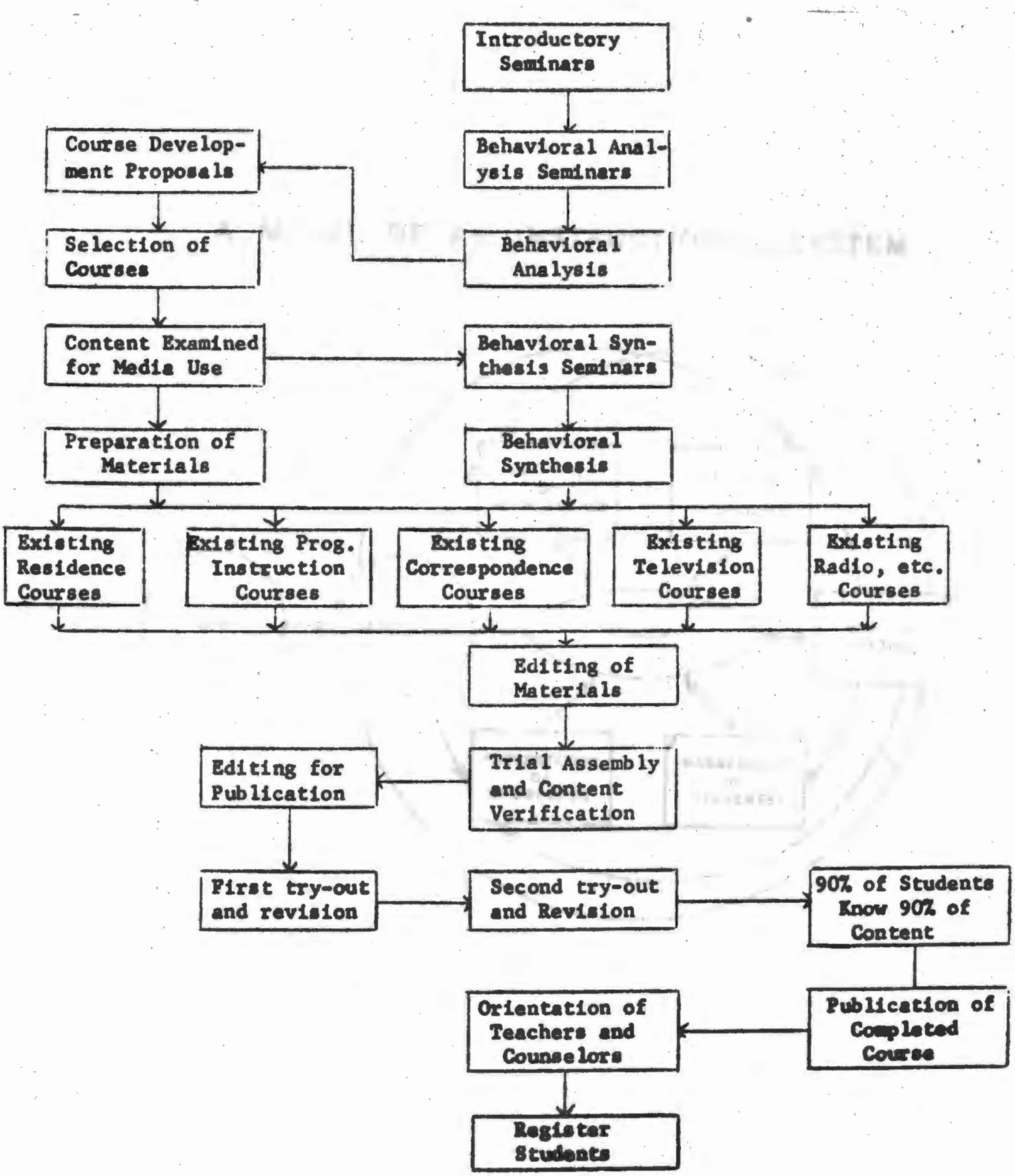

Fig. 40.--Course design sequence

A MODEL OF AN INSTRUCTIONAL SYSTEM

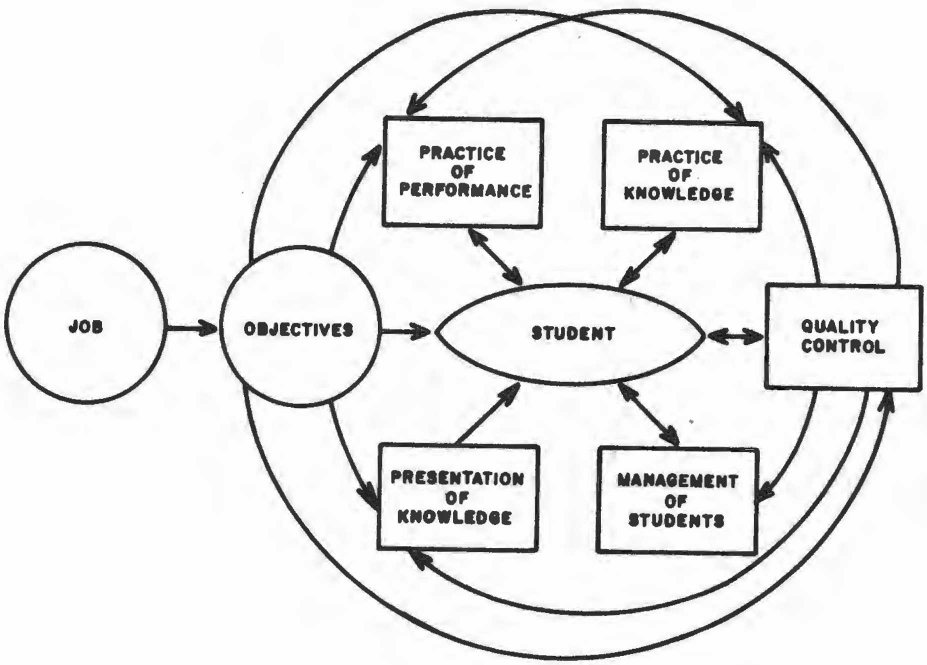

Figure 41.

> The best available basis for the needed matching of media with objectives, is a rationale by which the kind of learning involved in each educational objective is stated in terms of the learning conditions required.[49]

In an endeavour to provide a practical guide to the learning conditions referred to above, Mager has adapted Gagné's eight types of learning[50] in the following form.

1. Discrimination (Knowing when to do it, knowing when it's done).
2. Problem-solving (How to decide what to do).
3. Recall (Knowing what to do, knowing why to do it).
4. Manipulation (How to do it).
5. Speech (How to say it).[51]

A look-back at Figure 33 will provide an example of the manner in which Mager suggests use of these learning modes in the classification of task steps. It must be noted that in this example the instructional intent is to teach the specific task. If, as is often the case, student performance of the task itself is impossible or undesirable within the training environment, and the requirement is performance of some related enabling activity, it would seem that Mager's classification system still possesses a great deal of merit.

Smith[52] has also made valuable contributions to

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[49] Leslie J. Briggs, et al., Instructional Media: A Procedure for the Design of Multi-media Instructions, a Critical Review of Research and Suggestions for Future Research (Pala Alto, California: American Institute for Research, 1965), p. 176.

[50] Robert M. Gagné, Conditions of Learning (New York: Holt, Rinehart and Winston, Inc., 1965), p. 308.

[51] Mager and Beach, op. cit., pp. 44-51.

[52] Robert G. Smith, Design of Instructional Systems, op. cit., pp. 21-27.

course design in a recent report in which he discusses the value of whole and part task practice, the provision of adequate and timely presentation of knowledge of results during task and knowledge practice, critical sequencing of material, provision for student motivation, response modes, discrimination, and serial learning as points of learning theory to be considered. An equally useful discussion of these factors in relation to industrial training is provided by McGehee and Thayer.[53] Miller[54] applies much the same approach to the planning for and development of training devices, an important issue in many training and educational designs. In a more limited fashion Glaser[55] and Trow[56] have described the development of instructional procedures and the selection of various media of presentation using the Systems Approach in educational design.

At this point it can be said that once the objectives have been established, the methods to be employed in achieving them can be selected from a vast array of old as well as new techniques and methods. The Systems Approach provides a discipline which enables the designer to try new

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[53] McGehee and Thayer, op. cit., pp. 126-224.

[54] R.B. Miller, Handbook of Training and Training Equipment Design (Pittsburgh: American Institute for Research, 1953), pp. 268-275.

[55] Robert Glaser, "Components of the Instructional Process," in Educational Technology, edited by John P. DeCecco (New York: Holt, Rinehart and Winston, 1964), pp. 68-76.

[56] William Clark Trow, Teacher and Technology - New Designs for Learning (New York: Appleton-Century-Crofts, 1963), pp. 114-147.

methods and strategies with far less fear and trepidation than that experienced in the more conventional design. All design features must be validated in terms of student achievement of the established objectives so that success or failure of instructional procedure or strategy is clearly evident.

Validation and Evaluation

The very essence of the Systems Approach to education and training is the validation and evaluation by feedback. External feedback from the operational environment on graduate performance provides vital information concerning the whole instructional system. Internal feedback with regard to student achievement of system objectives provides the instructor/teacher/programmer with information which is critical to the improvement of the instructional design and the methods practiced. Finally feedback to the student as he progresses each step of the way towards the objectives is considered to be an essential feature of the learning environment.

The greatest problem in developing this feedback would seem to be caused by the general attitude to testing devices as they are presently employed in assessment of student and system.

In a recent article by Bloom dealing with testing procedures and their relationship to student mastery, he makes the following critical comment:

> Each teacher begins a new term (or course) with the expectation that about a third of his students will adequately learn what he has to teach. He expects about a third of his students to fail or to just "get by". Finally he expects another third to learn a good deal of what he has to teach, but not enough to be regarded as "good students". This set of expectations, supported by school policies and practices in grading, becomes transmitted to the student through the grading procedures and through the methods and materials of instruction. The system creates a self-fulfilling prophecy such that the final sorting of students through the grading process becomes approximately equivalent to the original expectations.[57]

If this state of affairs is to continue it will be impossible to validate any systematic approach to education or training, because "getting by", as Bloom states it, is not the intended student outcome for which the system is designed. Bloom continues with a well-documented discussion of student aptitude and the manner in which the normal "bell" curve of distribution has been used to convince student and teacher alike that complete mastery on the part of the student comes to very few and failure on the part of many students to achieve mastery is here to stay. However Bloom clearly establishes that research has indicated that by excluding those very few students who have special disabilities for learning of certain kinds (tone-deaf, color blind, etc.) there are about 95% of all students who can achieve mastery of most subjects, of the grade in which they find themselves. Distribution of students becomes a

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[57]Benjamin S. Bloom, "Learning for Mastery," UCLA Evaluation Comment I (May, 1968), 1.

matter of time rather than achievement. He states:

> It is assumed that it will take some students more effort, time and help to achieve this level than it will other students . . .. One basic problem for a mastery learning strategy is to find ways of reducing the amount of time required for the slower student to a point where it is no longer a prohibitively long and difficult task for less able students.[58]

Of course this idea of student mastery is not new to instructional programmers. The United States Air Force, which has provided leadership in this field, established the mastery requirement for all students using the programmes produced by specifying that no programme would be acceptable for field use unless the following criterian had been met: " . . . 90% of the students must score 90% or above on a comprehensive test covering all the course objectives."[59] All reports indicate that they have never had to reduce this standard at any time for any reason and mastery of critical objectives has been the happy lot of large numbers of USAF trained personnel. This, of course, could not have been achieved with a traditional concept of testing based, as Trow suggests, on the idea that " . . . much of what the student are supposed to learn is actually regarded as useless since they 'pass' whether they learn it or not."[60] He elaborates on this point by

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[58] Ibid., p. 4.

[59] James E. Briggs, "Programmed Instruction Breakthrough in Air Force Training" in Trends in Programmed Instruction, op. cit., p. 132.

[60] Trow, op. cit., p. 39.

suggesting that when the student is scored on tests in relation to others in the class (norm-oriented) no one really knows what the student has learned or what he has not. While this method of testing does not appear to wrong the teacher, consider the student's position where he may not be able to assess his <u>own</u> degree of mastery. Also it is extremely difficult to detect poor learning conditions because norm-oriented testing does not often test the achievement of well established objectives.

In the Systems Approach the establishment of objectives, representing the critical student performance to be achieved, precludes the use of norm-oriented approaches to assessment. Validation of the processes and strategies of the system demand a clear-cut indication of each student's achievement in terms of the objectives, not in terms of the relative achievement of the other students. This represents the first phase of system validation.

The second phase of the validation/evaluation process must deal with performance of the graduate in the "real world" - how well does the graduate function in the operational situation? If unsatisfactory performance results, the trainer (and educator) must be able to identify the nature of the failure and must endeavour to determine the cause of the failure. This external feedback is critical to the evaluation of the established objectives which in turn will affect every other facet of the design.

Cummings[61] has illustrated the feedback process clearly in a recent paper and Figure 42 has been taken from it as an example of a Systems Approach model. Considering the structure of the Systems Approach as Cummings and others have described it and convinced that a systematic development of training was necessary if rapidly changing operational needs are to be met in a modern military force, the Training Command of the Canadian Armed Forces has established a policy to apply the Systems Approach to training throughout the Armed Forces. In the light of the description of the Systems Approach provided in this Chapter, Figures 43 and 44 are self explanatory and outline the processes which must be established. Figure 45 depicts the model which will serve as a basic guide to all subsequent systems development within the Canadian Armed Forces. Appendix C provides a description of a facet of this development now in progress within the Canadian Armed Forces. While it does not provide a complete picture it does serve as an example of the Systems Approach in action.

Summary

The characteristics of the Systems Approach to education and training strategy, as it has developed in recent years, have been briefly described in this Chapter. The principal emphasis of this approach, as a result of its affiliations with Human Engineering and Programmed Learning

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[61] Roy J. Cummings, <u>op. cit</u>., p. 29.

FAA Academy Training System

Design and Preparation is Shown on the Left and Feedback on the Right

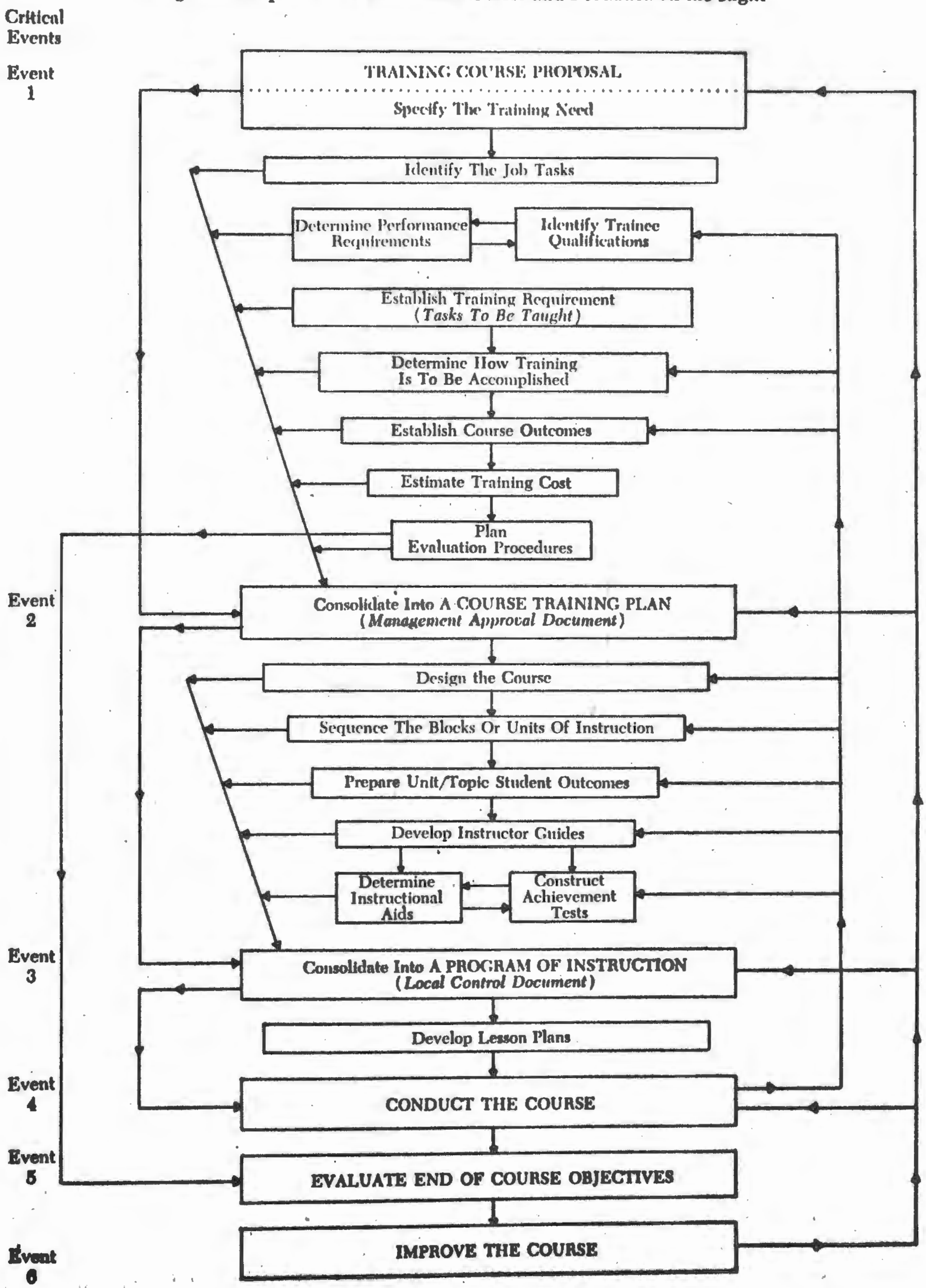

Figure 42.

ANALYSIS OF REQUIREMENTS QUALITATIVE

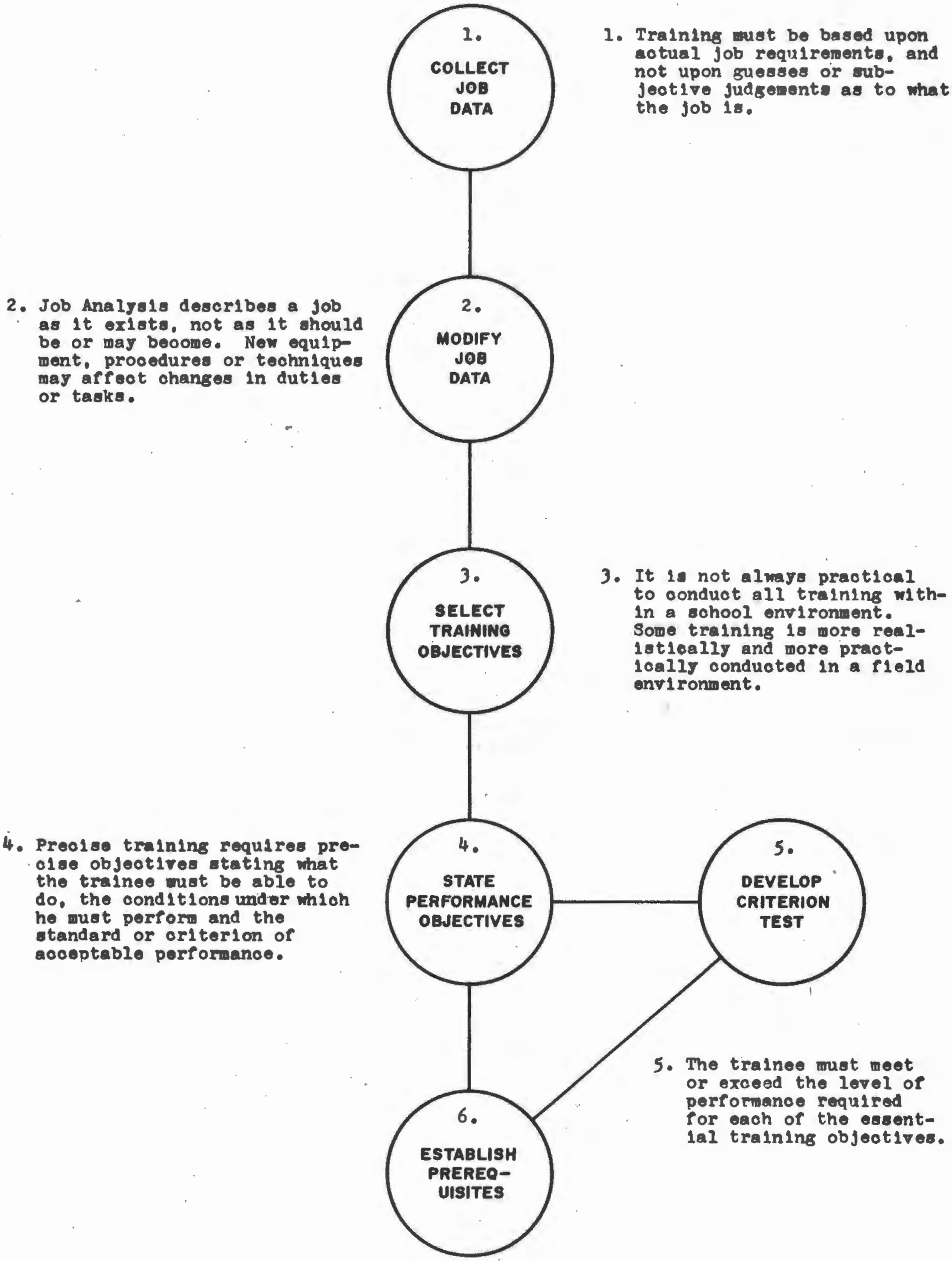

Figure 43.

THE SYNTHESIS OF TRAINING

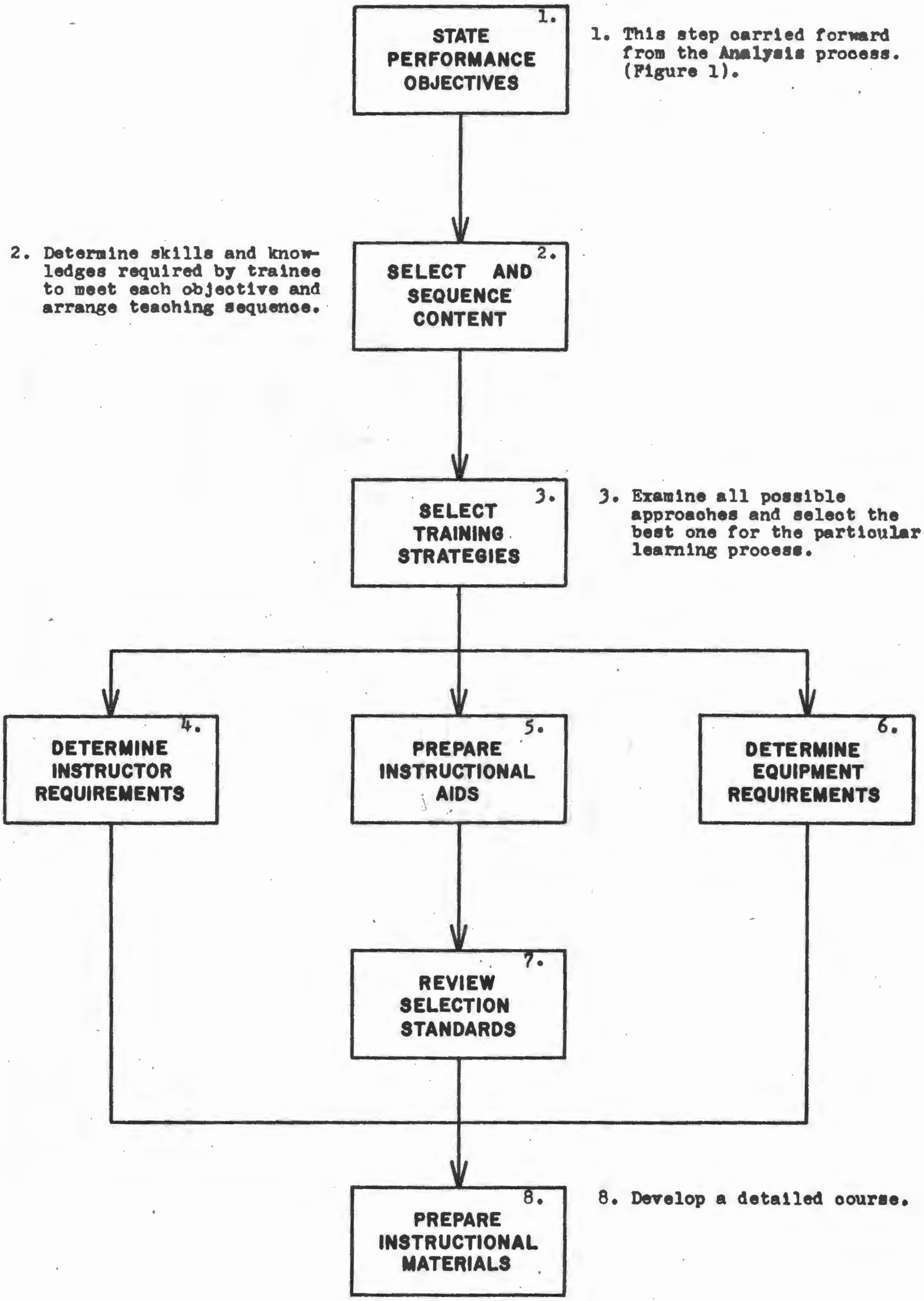

Figure 44.

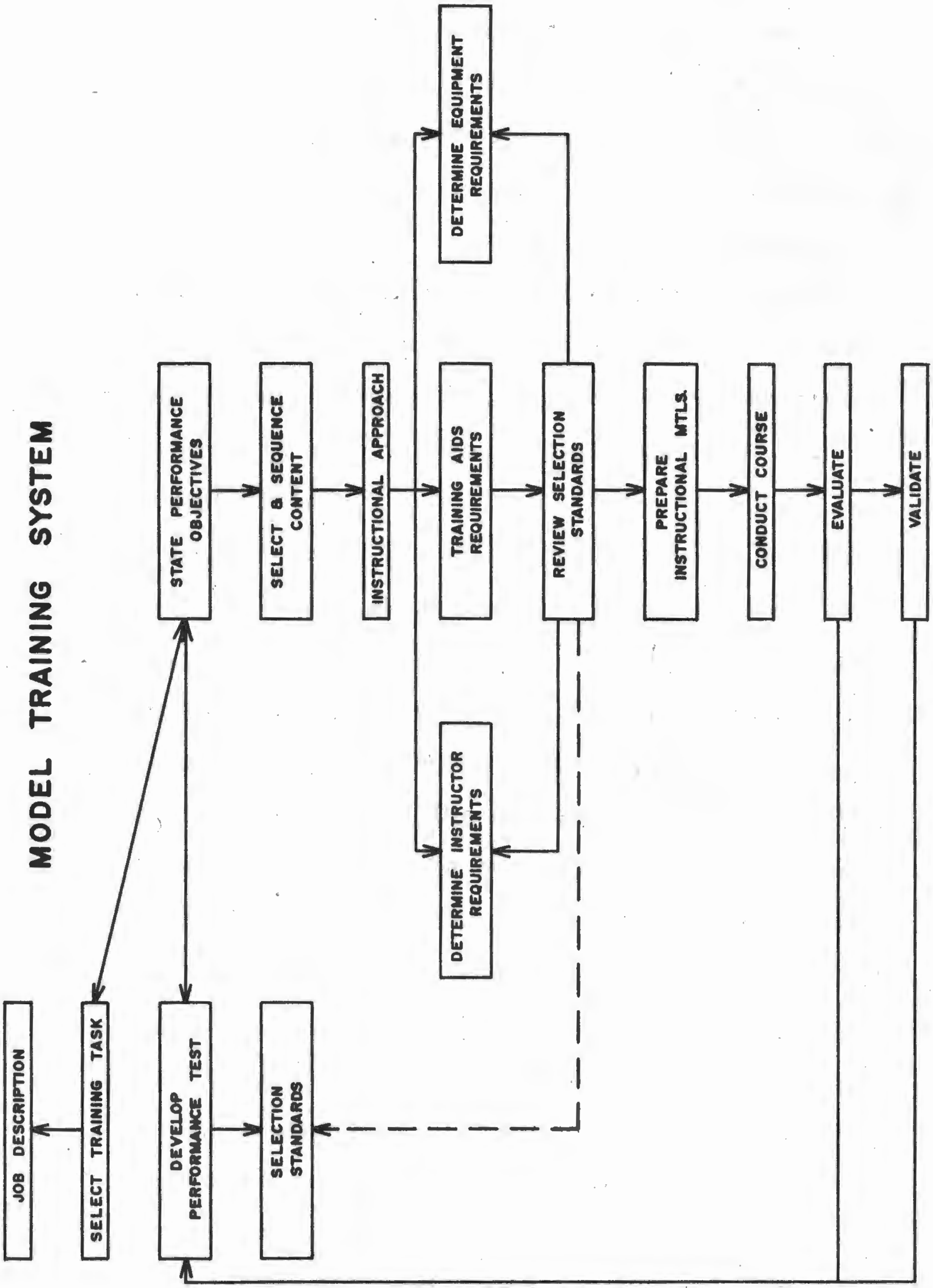
MODEL TRAINING SYSTEM
JOB DESCRIPTION
SELECT TRAINING TASK
DEVELOP PERFORMANCE TEST
SELECTION STANDARDS
STATE PERFORMANCE OBJECTIVES
SELECT & SEQUENCE CONTENT
INSTRUCTIONAL APPROACH
TRAINING AIDS REQUIREMENTS
DETERMINE INSTRUCTOR REQUIREMENTS
DETERMINE EQUIPMENT REQUIREMENTS
REVIEW SELECTION STANDARDS
PREPARE INSTRUCTIONAL MTLS.
CONDUCT COURSE
EVALUATE
VALIDATE

Figure 45.

has been on the centrality of the learner. In view of this learner-oriented bias, it seems convenient to summarize the System Approach in terms of the advantages such as approach should provide in the interest of improved student learning.

1) Job/Task/Need analysis provides a clear definition of the nature of the activities in which the graduate is expected to participate at the termination of education/training at any particular level. Both student and trainer/educator are informed of the ultimate requirements of the parent system.

2) The development of training/educational objectives provides the link between the learning and operational environment. While the job/task/needs analysis provides what are often long term goals for the student, the objectives provide short term goals. The student has every right to expect these goals to lead him to acceptable operational performance and the system designers has an obligation to ensure their ultimate relevancy.

3) The course design must represent the best efforts of the trainer/educator in an endeavour to develop an environment in which students will learn. Student mastery of relevant objectives must be the rule rather than the exception; and if the designer expects the students to work for what they

need, the system must assure them, by its very nature, that their labours will not be in vain.

4) The evaluation process to be employed must provide the student with accurate assessment of his progress with respect to the degree of mastery of sub-objectives and objectives all along the way and not in terms of the class norms. This is evaluation's most urgent requirement. The system elements can then be assessed and validated in terms of its students' achievement within the system and after graduation.

In these four key elements are expressed the very strength and promise of the recommended practice of the System Approach to Education and Training.

CHAPTER IV

IMPLICATIONS OF THE SYSTEMS APPROACH FOR EDUCATIONAL AND TRAINING DESIGN

This thesis has provided a comprehensive description of the nature of the Systems Approach as it has been developing in recent years within the framework of educational and training environments. The contributions of Programmed Learning and Human Engineering to the evolutionary development of this highly-structured and disciplined approach have been discussed in some considerable detail. It would seem of value at this point to conclude with a discussion of the manner in which the Systems Approach may be employed in future educational and training design and an indication of some of the implications of such employment.

While innovation with intent to improve learning conditions in existing educational and training systems has been clearly in evidence under the excessive pressures of technological advances since World War II, most changes appear to have been of a very limited nature in highly localized environments. The Systems Approach firmly recommends dealing with the real need for innovation on a much wider base, involving all levels of control within the educational and training systems which presently exist. The point of view which seems implicit in the structure and the processes of the Systems Approach is that significant improvement in the design of more effective learning environments is least likely to result from the oft-used, piecemeal approach which has characterized the introduction of many products and techniques of the so-called instructional technology. Dust-covered teaching machines with no suitable programmes, neglected audio-visual equipment in closets, little-used television monitors mounted in classrooms are but a few of the examples which offer mute evidence of enthusiasm which faded in the face of seemingly insurmountable problems arising from the lack of systematic design and implementation procedures.

From the examples provided in the previous chapter, it seems fair to say that the Systems Approach has reached the point in its development where it can provide a feasible alternative to conventional training and educational design. It can be expected to avoid many of the pitfalls and heartaches experienced by educational and training innovators who have tried to solve their problems within the confines of the classroom disciplined, primarily, by the subject-matter to be taught. In consideration of the implications of applying the Systems Approach to both training and educational design, it must be recognized that there have been more rigorous applications in the training field than in the educational field. The reasons for this would appear to be as follows:

1) The Systems Approach had its origins within

structures which were developed to <u>train</u> personnel rather than <u>to educate</u> them. This must be interpreted with a view to the traditional meaning of these two terms and the somewhat academic distinctions which have arisen.

2) The goals of the parent system of which education may be viewed as a sub-system, are truly much broader than those towards which most of the efforts of a training sub-system must be directed. These goals tend to permeate the whole educational structure even down to the classroom level. While this is desirable to the extent that the teacher is imbued with the overall goals of the system, it is often used as a reason for not needing to identify and clearly define just what day-to-day classroom practice must achieve if the overall goals are to be met by the students.

While these two reasons appear to have greatly influenced the lack of interest which educators have evinced in the System Approach, it must be realized that the broader the goals, the more difficult will be their achievement without some form of systematic ordering of requirements which will be meaningful at each level to teacher and student alike. In this situation, it can be seen that one of the critical differences between education and training lies in the degree of specificity of the overall goals. Generalized goals would seem to require learning of different behaviors than highly specific ones and herein lies the crux of the matter. The Systems Approach does not apply itself to the attainment of specific goals only, as one might be led to believe as a result of its training birthright, but suggests that given overall goals, a systematic development of performance objectives must be carried out to identify the type of performance which will be required of the learner if he is to attain the parent system goals. From this requirement arise the first two implications of the Systems Approach to education and training.

1) The overall goals of the parent system must be carefully established and analyzed to ensure clarity of content and intent. In systems designed primarily to prepare their personnel for gainful employment in highly specific activities, a task analysis will provide the necessary specifications. In systems designed to prepare graduates to function satisfactorily in an environment defined by broad social, economic and political restraints, an analysis of a different sort will be required.

2) The overall goals of the parent system must be interpreted in terms of performance objectives which learners will be expected to achieve within the learning environment. The differences which will occur between parent system goals and sub-system objectives

will depend on the degree of realism which can be built in to the learning environment. This gap is of vital concern to all instructional designers and it would seem that the extent of it may mark another real difference between education and training design requirements which needs careful consideration particularly during objective development and sequencing stages.

The establishment of the required complex patterns of learner behavior in the form of performance objectives to be achieved within the learning environment, promises to provide considerable clarification of the elements and functions which are relevant to the design of that environment. Much of the process of design will have to be carried out in the educational/training establishments which will involve supervisors, teachers and instructors in a number of significant ways. In this regard, three further implications of the System Approach seem evident within the design phase.

3) The educational/training establishment itself must be brought into a dynamic role with regard to innovation. It should be a place in which change is clearly recognized as characteristic of life itself. From an instructional point of view, the establishment should be a site of innovation.

4) Educational/training technology, as represented by computer-assisted instruction, programmed

instruction, instructional television, and more especially, educational and training system analysis, represents an urgent challenge for the teacher/instructor as well as for the whole educational/training system.

In a succinct commentary on the impact of the advancing technology on the public school teacher, Geis clearly supports the role changes envisaged by the Systems Approach.

> To the extent that the teacher is an audio-visual device she is doomed by the development of more efficient and more sophisticated hardware. To the extent that she is a reinforcer dispenser on a random delivery schedule she is threatened today not only by theories of instruction and learning but by new approaches to child development and maturation. In an innovative system a teacher could pursue many other roles; she could help design, develop, try-out and evaluate large and small scale innovations. She could assume a more dignified and, I think, more rewarding position as manager of, and investigator of, student learning.[1]

5) In order to make an innovation work the educational/training establishment must spend an enormous amount of its resources adapting that innovation to its own needs, constraints, and strengths. Innovation, as it is referred to here and within the structure of the Systems Approach does not refer merely to newness or change. It refers to systematic, progressive and cumulative

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[1]George L. Geis, Developing a Strategy for Innovation, A Report on Flics Project Supported by USOE Grant 3-6-000927-1969 (Chicago: American Educational Research Association, 1968), p. 8.

change whereby the production of better and better instructional designs will result in the improvement of learning conditions.

If the sub-system objectives are complex in nature, as many of them will be, the ingenuity of the designer will be taxed to the utmost. However, with the objectives clearly defined, the designer can see exactly what he must achieve with the learners. Following learning environment design and its implementation, a further benefit is proposed within the Systems Approach - that of validation. The objectives are the criterion of success or failure of the design. This suggests two additional implications of the Systems Approach.

6) <u>Assessment of learner progress within the educational/training system must be in terms of the performance objectives.</u> This requires a re-assessment of traditional examination and evaluation practices with a view to performance-oriented rather than normal-oriented testing vehicles. The value of the former type is clearly seen in its ability to point towards the extent and cause of failure-to-learn on the part of the learner. If extent and cause of failure can be identified, the cure of the condition may be obvious or at least at hand. The internal feedback provided here keeps the design phase dynamic in its strategies and functions.

7) <u>Assessment of graduate performance in the parent system environment is required to ensure that achievement within the educational/training sub-system is preparing the graduate adequately</u>. Interviews with graduates, employers, advanced trainers and educators are suggested as a few of the sources of the external feedback necessary to ensure relevancy of sub-system learning conditions. Often unsolicited feedback such as complaints from employers and student riots in university indicate that the instructional designer may have lost sight of the parent system requirements. This kind of feedback is of course very sporadic and highly generalized so that it does not help much. Carefully designed feedback techniques and processes are necessary if random and sometimes destructive criticism is to be avoided.

Implementation of the various processes which the Systems Approach recommends will have a final profound implication for both training and educational design and practice.

8) <u>The Systems Approach requires that the design and innovation procedures be developed from an overall study of the entire system.</u> This obviates the highly individualized and personalized changes and resistance-to-change which

often develop without a view to the overall requirements and needs of the system. It does not suggest that new ideas would not be entertained from the personnel at the various levels of control, but rather insists that such suggestions be developed in terms of the overall requirements of the system and the various types of feedback which must be established. At the risk of oversimplification of the complexity of the processes, Table 3 provides a comparison between the suggested means of implementation in typical training and educational systems. The training side has proven itself in a number of highly successful systems, a representative selection of which were cited in the previous chapter. Implementation of the Systems Approach within existing educational structures has not progressed far enough in any of the on-going projects reported to-date to provide substantial evidence. Only the guidelines can be provided at this point. The suggested structure on the left side of Table 3 must therefore be considered as a form of interpolation from the more highly developed training models.

It would be hoped that the premise advanced herein respecting the application of the Systems Approach to educational and training design will provide a framework within which further research and study may be carried out in the interest of improved learning conditions in both educational and training environments.

APPENDIX A

ANNOTATED BIBLIOGRAPHY OF SELECTED READINGS ON APPLICATIONS OF PROGRAMMED LEARNING[1]

Books

*Edling, Jack V., et al. (eds.). Four Case Studies of Programmed Instruction. New York: The Fund for the Advancement of Education, 1964.
This report provides a very comprehensive and objective description of the use of PI in four school districts.

Hughes, John L. (ed). Programmed Learning - A Critical Evaluation. Chicago: Educational Methods, Inc., 1963.
This text is a compilation of five reports and discussions which followed during a meeting at Rochester, New York (1962) sponsored by the Foundation for Research on Human Behavior to examine the emerging field of programmed learning and to consider the implications of this technique for industrial training. This approach to PI provides the reader with an interesting insight into the "process" and the use of the "product".

*Lumsdaine, A. A. and Glaser, Robert (eds.). Teaching Machines and Programmed Learning - A Source Book. Washington: National Education Association, 1960.
As its title implies, this text is a "source" book and it is a must for all interested in developing a background knowledge of programming.

Ofiesh, Gabriel D. Programmed Instruction - A Guide for Management. New York: American Management Association, 1965.
In addition to a general section on the development of Programmed Instruction and the Systems Approach, this text provides 35 case histories describing the use of PI in a variety of industrial and armed forces training environments.

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[1]All items marked with an asterisk (*) are held by the Staff Officer (Programmed Learning) Fleet School, C.F.B. Halifax and are available to interested students for reference purposes.

*Ofiesh, Gabriel D., and Meierhenry, Wesley C. (eds.). Trends in Programmed Instruction. Washington: National Education Association of United States, 1964.

This text is a collection of the papers presented at the first annual convention of the National Society for Programmed Instruction. The value of this collection lies in its representation of the nature and impact of PI on Education, Armed Forces training and Industrial training.

Articles and Periodicals

*Arcarese, Lawrence C. et al. "Independent Learning of Music Fundamentals," National Society for Programmed Instruction Journal, VI (November, 1967), 9-12.

A discussion of a project to investigate the use of PI in the field of music fundamentals. An interesting application.

Cather, Harry E. "Programmed Instruction in the Aerospace Industry," Training and Development Journal, XXI (October, 1967), 29-32.

This article reports the results of a survey of seventy firms in the Aerospace Industry of the United States which indicates number of firms using PI, the form of PI used, the results of PI and the amount of PI replacing conventional instruction. PI especially successful in basic and fundamental training and in familiarization and refresher courses.

*Bata, Thomas J. "If the Shoe Fits.....," Canadian Training Methods, I (March-April, 1968), 10-12.

Describes use of programmed learning for on-the-job training of employees in English, French, and Spanish.

*Chadwick, Clifton B. "Instructional Management: A Defined Role for the Teacher," National Society for Programmed Instruction Journal, VII (February, 1968), 5-7.

Article describes a new role for the teacher in the classroom where PI allows an opportunity for the teacher to concentrate more on student and less on subject matter.

*Clark, William. "Simpson's Trainers Sell Service," Canadian Training Methods, I (March-April, 1968), 20-22.

Illustrates use of programmed learning to teach sales systems and cash register operation to sales staff.

*Crawford, Harold F. "A Note of Caution on Listening Training," Training and Development Journal, XXI (May, 1967), 23-28.
This is a report on the use of one of the first and most highly touted program-on-tape "Effective Listening". While finding it very useful at Honeywell Ordnance Division, the author points up some precautions to be followed when using the program.

*Crawley, Donald. "The Pilot: Best Trained Man," Training in Business and Industry, IV (September, 1967), 31-34.
Use of programmed instruction and the programming process to train pilots in Trans-World Airlines. Illustrates development of feedback devices to improve learning in theoretical as well as practical learning areas.

*Deterline, William A. "An Empirically Designed and Developed Multimedia System," National Society for Programmed Instruction Journal, VI (March, 1967), 3-6.
A very interesting paper which describes the use of programming principles to teach physical skills such as soldering. A very novel approach to the solution of a training problem.

*Drekmann, Ralph A. "Programmed Learning: The State-of-the-Art for Training Practitioners," Training and Development Journal, XXII (April, 1968), 51-60.
Provides an excellent presentation of the way industry looks at the product and the process of programming.

Dunyworth, D. "Experiences with a Modern Language Program," Programmed Learning, III (October, 1966), 171-175.
This paper suggests that the introduction of programmed learning can facilitate the removal of the problems of time shortage, lack of concentration, and lack of motivation frequently encountered in language courses.

*Fanning, Robert J. "PI Use in New York City Schools," National Society for Programmed Instruction Journal, IV (September, 1965), 9-10.
Writer discusses the use of programmed material in the subject areas of slide rule, computer mathematics, career mathematics and reading.

*French, Henry P. "A Programmed Unit in Chinese Culture Concepts," National Society for Programmed Instruction, VI (September, 1967), 10-15.
This article illustrates the use of PI in teaching concepts using the intrinsic method. Sample frames of the program are included.

Glaser, Robert. "Toward the New Pedagogy," Educational Technology (Spring, 1967), 49-56.
An educational researcher offers some interesting opinions on the prospects, in the schools of tomorrow, for the individualization of instruction, computer-assisted instruction and psychologically based instructional design.

*Harmon, Paul. "Programmed Instruction at a Job Corps Centre," National Society for Programmed Instruction, VII (May, 1968), 4-9, 18.
This report is on a Job Corps curriculum and the role that programmed learning can play in it. It deals with the relationship between the type of students and their attitudes toward the Job Corps curriculum.

*Issing, Ludwig J. "Programmed Instruction in West Germany -- Development and Present State," National Society of Programmed Instruction Journal, VI (July, 1967), 16-19.
A comprehensive survey of use of PI in German Schools and Industry.

*Mager, Robert F. "Deriving Objectives for the High School Curriculum," National Society for Programmed Instruction Journal, VII (March, 1968), 7-14.
Mager discusses the careful development of highly specific educational objectives and proposes that this process would have utility to curriculum developer, teacher and student as a first important step in the visible improvement of education.

*McClintock, Marion., et al. "Orienting the New Employee with Programmed Instruction," Training and Development Journal, XXI (May, 1967), 18-22.
Describes the development and trial of an in-house program for use with new employees of Union Electric Company. The program was developed to shape concepts and attitudes and successfully achieved its objectives.

*Nagay, John A. "Trends in Programmed Instruction During 1965-66 in Military Training in the NATO Nations," National Society for Programmed Instruction Journal, VI (April, 1967), 17-20.
An interesting synopsis of the developing interest in PI among the military training commands of NATO nations.

*Paden, Donald W. "Instructional Television and the Programming Process," National Society for Programmed Instruction Journal, VI (July, 1967).
Observations on the combination of the instructional programming process with educational television. It includes a discussion of testing students entering behavior, objectives, and establishment of criterion tests.

Rocklyn, E. H., _et al_. "Olivetti Programming: A Useful Programming Variation," _Training and Development Journal_, XX (January, 1968), 40-46.

A very interesting description of the use of programmed learning to teach mechanical and electrical principles of office machines. Sample materials of the programme are included.

Schuttenberg, E. M. "Yes, Trainers can be Responsible for Their Own Learning," _Training in Business and Industry_, IV (September, 1967), 24-26.

Use of programmed instruction and the programming process to train instructors in American Airlines.

*Sherrill, James L. "Programmed Instruction in the Army FY66," _National Society for Programmed Instruction Journal_, VI (July, 1967), 10-13.

Paper gives an overview of training conducted by the U.S. Army, the effort with programmed instruction, the impact of programmed instruction and predictions of future use of PI in U.S. Army.

*Smith, M. "What it Takes to Train an Air Canada Passenger Agent," _Canadian Training Methods_, I (March-April, 1968), 15-17.

Illustrates use of programmed learning to teach passenger agents the electronic filing system in use in Air Canada.

*Wood, Margaret. "Programmed Instruction Teaches Library Usage," _National Society for Programmed Instruction Journal_, IV (October, 1965), 8-9.

Writer describes the development and use of programmed instruction to teach library skills. The students using program reached the required objectives.

*Zaner, Theodore. "Research Frontiers for Management Training," _Training and Development Journal_, XXI (June, 1967), 19-24.

This paper examines the potential of a number of relatively independent training approaches that have emerged including programmed instruction and relates them to management training.

Reports

*Kopstein, Felix F., et al. Preliminary Evaluation of a Prototype Automated Technical Training Course. A Technical Documentary Report No. MRL-TDR-62-78 prepared for the Aerospace Medical Division, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio. July, 1962.

A preliminary evaluation of branching intrinsic programming for automated training in a communications Electronic Principles course employing the Auto Tutor MK 1 teaching machine. The students learned adequately.

Eckstrand, Gordon A. Teaching Machines in the Modern Military Organization, A report presented at the NATO Symposium on Defence Psychology, NATO Headquarters, (Porte Dauphine), Paris, France. July, 1960.

In this report the military use of teaching machines and the need to make their widespread use a reality are discussed.

Unpublished Materials

*French, Henry P. "Programmed Self-Instruction in Asian Studies and the Affective Domain," Paper read at the Annual Convention of the National Society for Programmed Instruction, San Antonio, Texas, April 19, 1968. (Mimeographed).

This is a second paper by French on this subject and re-affirms that PI can operate successfully in the affective domain. This is one of the few research projects carried out with respect to the affective domain and PI.

*Numberger, Robert G. "The Psychological Impact of Active Student Response Upon Learning and Retention of Subject Matter Presented by Television Medium." Paper read at the annual convention of the National Society for Programmed Instruction, San Antonio, Texas, April 19, 1968. (Mimeographed).

Discusses the improvement in learning which results in ETV when the "active response" programming principle is implemented.

*Pierleoni, Robert G. "The Affective Measurement of a Programmed Unit on American Political Attitudes and Positions." Paper read at the annual convention of the National Society for Programmed Instruction, San Antonio, Texas, April 19, 1968. (Mimeographed).

This paper is of vital importance for it discusses the use of programmed learning in the affective domain. That an instructional program can be used to develop attitude changes is interesting. Also of value is the discussion of means of measuring of attitudinal changes.

*Wilds, Preston Lea and Zachert, Virginia. "Teaching Inquiry Skills in Medicine." Paper read at the annual convention of the National Society for Programmed Instruction, San Antonio, Texas, April 19, 1968. (Mimeographed).

This presentation clearly indicates the utility of PI principles in problem-solving in the field of medicine. The paper contains interesting samples of the instructional materials used.

APPENDIX B

EXAMPLES OF RECENT DEVELOPMENTS IN PROGRAMMED LEARNING

The work of the three principal investigators in the main stream of early instructional programming has been described in Chapter II. However, as one might expect with such a newly developed concept, there have been many variations on the original themes. In this Appendix, four of these variants are briefly described in the hope that they will serve to broaden the reader's view of this new discipline, while encouraging him to consider possible applications within his own area of educational or training endeavour.

The first example presented is a process known as Contingency Management and represents an application of Skinner's reinforcement theory in a conventional classroom in an interesting manner.

Contingency Management

Contingency Management was first implied by B. F. Skinner when he suggested that learning could be shaped and improved by the provision of a large number of reinforcement contingencies.[1] The available reinforcers

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[1]B. F. Skinner, "The Science of Learning and the Art of Teaching," Harvard Educational Review, XXIV (Spring, 1954), 92.

were classified as primary (food, water etc.) and secondary. The secondary reinforcers were conditioned by having been paired with primary physiological reinforcers and often possessed emotional concomitants. Approval, attention and affection of parents, teachers and peers were all considered to be effective as reinforcing events.[2] As indicated in Chapter 2, Skinnerian programs were developed to manage contingencies and enhance learning.

The application of reinforcement and the law of effect received a "boost" by Premack who proposed a theory of reinforcement which promises to increase the generality of application. Hilgard describes the theory in the following manner:

> . . . Premack's argument stems from noting an implicit assumption contained in previous formulation from the law of effect . . . . The responses or activities to be reinforced are neutral or of no intrinsic value to the subject. But suppose that we take an opposite viewpoint, that the organism engages in a variety of activities (including eating, manipulating, playing, etc, ad infinitum) that vary in their intrinsic value for him. I imagine further that by some means we have ordered these activities in a ranking from most to least preferred, in order A, B, C, D, . . .
>
> . . . .
>
> . . . Premack argues that the only sensible formulation ties the reinforcement relation to this preference ordering: a given activity can be used to reinforce those of lesser value but not those of higher value.[3]

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[2]B. F. Skinner, Science and Human Behavior (New York: The MacMillan Company, 1953), pp. 76-81.

[3]Ernest R. Hilgard and Gordon H. Bower, Theories of Learning (3d ed. rev.); New York: Appleton-Century-Crofts, 1966), p. 483.

Transferred to the learning environment, Premack's theory can be restated to suggest that low value behavior can be reinforced by a "promise" of an opportunity to engage in high value behavior. ("You can go swimming after you have mowed the lawn"). A research and development group at the Westinghouse Research Laboratories under the direction of Dr. Lloyd Homme has carried out several projects in contingency management based on Premack's theory.

Homme, in dealing with contingency management and motivation, states:

> There is a growing technology concerning the application of the laws of behavior. In the application of the laws of behavior to practical affairs, the most important factor is motivation. Although motivation is widely held to be a complex phenomenon . . . the practical problem of motivation is reduced to this simple question: What reinforcers are available?[4]

Homme goes on to indicate that Premack's theory designates many reinforcers within the learning environment if the "teacher" can detect high and low probability behavior and use the high probability behavior to reinforce low probability behavior. As Homme states it: "one simply takes notice of which behaviors are reinforcing responses, then permits this behavior to occur only after behavior one wishes to reinforce".[5] He suggests that the difficulties in the control of behavior are not due to lack of reinforcers or lack of knowledge about how to use them, so much as they

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[4]Lloyd E. Homme and D. T. Tosti, "Contingency Management and Motivation," National Society for Programmed Instruction Journal, IV (September, 1965), 14.

[5]*Ibid*.

are due to a failure to systematically apply what is known. He also warns that "either one manages the contingencies or they get managed by accident. Either way, there will be contingencies, and they will have their effect".[6]

In 1966 the Westinghouse Group reported considerable success in the use of contingency management in the teaching of English to a group of deprived school children at the San Felipe reservation. The unique feature of the program was the introduction of an Intermediate Consequences Box, a device which dispersed and controlled various reinforcers such as picture books, games, puzzles, which were given to the children upon successful completion of certain learning tasks. The items in the box were selected from a group of "things" which the children had already indicated were reinforcing.[7]

An interesting feature which the Westinghouse group introduced into the Job Corps training program was a device termed MENU, which was a list of high probability behaviors, such as chess, checkers, being allowed outside to smoke, etc. The student selected the high probability reinforcer he would take when he finished an assigned low probability task, say four questions in algebra. The Job Corps trainers have extended this feature into a "contract" with the

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[6] Ibid.

[7] Lloyd E. Homme and D. T. Tosti, "The Comprehensive Learner - Sensitive Classroom," Paper read at the Fourth Annual Convention of the National Society for Programmed Instruction, St. Louis, April 13-16, 1966.

students in which a set of cards has been prepared with the low probability learning tasks on one side and the corresponding reinforcing events on the other. As the student completes his contract he is permitted to partake in the selected high probability activity. It is significant that all the students with whom this process worked very successfully had weak school records and very poor relationships with teachers, principals and administrators.[8]

The techniques of contingency management have been applied in the classroom by regular teachers in a limited number of reported projects. In one such project[9] six volunteer classroom teachers were given three group and three individual instruction sessions in contingency management techniques. The object of the study was to determine whether six brief instruction sessions were adequate training to permit application of these techniques by teachers in their classrooms. Adequacy of such instruction was judged by improved behavior of the target child chosen by each teacher. Appreciable behavioral improvement in four of the six target children studied correlated with an observed increase in the teachers' use of behavior modification techniques. This increase in technique use was

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[8]R. Addison and S. Holder, "Uses of the Reinforcing Event in a Contingency Management System," Paper read at the Fourth Annual Convention of the National Society for Programmed Instruction, St. Louis, April 13-16, 1966.

[9]Dianne Knotts Carter, John E. Allen and Lynette A. Lmudock, "The Use of Contingency Management Techniques - An Applied Classroom Project," Paper prepared by the Bureau of Educational Research, University of Utah, Salt Lake City, 1967. (Mimeographed).

attributed to the instruction in such methods that they received. Of interest in this report is the fact that the teachers were not doing anything unusual in the classroom. They identified their problems and then used simple reinforcement techniques consistently to solve them. The reinforcers used in this study were primarily attention and praise.

Another interesting study has been reported by Murdock, and Della-Piana[10] in which a measure of the number of reinforcement contingencies utilized by teachers, who had received no previous special instructions was recorded on a special scale. As a preliminary test of the scale, it was used by observers to evaluate the classroom presentation of fifteen teachers who had been previously subjectively rated by the district supervisor. While there was some increase in teacher utilization of contingency reinforcement by the higher rated teachers, the correlation between subjective ratings and scale performance was only .205. However this result is not significant from the point of view of this description. Of considerable interest, however, was the scale of items for which teachers were scored. The score sheet is included as Figure 46 for reference purposes as it indicates the type of teacher activity considered important in the management of contingencies in the classroom.

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[10]Everett E. Murdock and Gabriel Della-Piana, "Reinforcement Contingencies in the Classroom," Paper read at the Fifth Annual Convention of the National Society for Programmed Instruction, Boston, April 19-22, 1967.

CONTINGENCY MANAGEMENT

ITEMS-TO-SCORE GUIDE

A.	C.S.E.	Contingent Stimuli Establishment.
	S^{rp}	Scored if teacher describes possibility of rewards.
	S^{rn} avoid	Scored if teacher describes punishment that will be applied unless appropriate behavior is shown.
	S^{rn} escape	Scored if teacher describes possibility of escape from punishment (already imposed) if appropriate behavior is shown.
B.	C.S.A.	Contingent Stimuli Applied.
	S^{rp}	Scored if teacher applies previously described rewards.
	S^{rn} avoid	Scored if teacher applies the punishment she had previously described, but had given the pupils a chance to avoid.
	S^{rn} escapes	Scored if teacher allows escape from punishment (already imposed) as she has promised.
C.	R.C.S.A.	Response Contingent Stimuli Applied.
	S^{rp}	Scored if teacher applies rewards not previously promised.
	S^{rn}	Scored if teacher applies punishment not previously promised.

Figure 46.

During the question period following the presentation of this paper Murdock indicated that in a study in progress, interim results were showing that teachers trained in the utilization of reinforcement contingencies were employing the technique successfully in the classroom, establishing three times as many contingencies per half hour as the untrained teachers assessed in the project discussed above.

In a later report by Tosti,[11] the place of contingency management within an instructional system is clearly defined. In the PRIME (Prescription, Instruction, Motivation, Evaluation) System, the motivation component is implemented by contingency management techniques. He suggests that the establishment of sound, lasting motivation is at once the most difficult step in building and applying an effective system of instruction. The initial interest intrinsic in most educational programs often wanes after the first few hours of instruction. Full attainment of the learning objectives designed into any given self-instructional program is very difficult unless proper motivation is provided. To keep the student in the learning environment or to keep him responding at a normal rate, his learning activity must lead to some preferred consequences.

The formal administrative techniques employed to provide positive consequences for all learning activities has been termed "contingency management", by Tosti and he

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[11] Donald T. Tosti, "Prime - - A General Model for Instructional Systems," National Society for Programmed Instruction Journal, VII (February, 1968), 11-15.

suggests that contingency contracts may be oral or written.[12]

Tosti goes on to report further success with the use of contingency contracts with students in the Job Corps and he concludes the report in this way:

> The PRIME model has been successfully employed in the establishment of several operating classrooms where research is being conducted to investigate procedures which may better achieve an effective, efficient, self-sustaining, and communicable educational system. Both the learners and the instructors like the way the system operates, and Corpsmen have made impressive grade level gains after 70 to 80 hours of instruction.[13]

While contingency management may appear to be off the main line of Programmed Learning, it represents an effective application of programming principles in a practical learning environment. It was included here as it represents a very active area of research and development in human learning and brings into the field a disciplined approach to the relationship between motivation and learning - an area frequently neglected by many.

While contingency management is a relatively new application of Skinner's early proposals, the second section of this appendix describes a form of instructional programming which has recently developed from the early work of Sydney Pressey. The common name of this form is Adjunct Programming.

Adjunct Programming

In recent years, Pressey has actively criticized

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[12] Ibid., pp. 14-15.

[13] Ibid., p. 15.

the programming efforts which have developed on the basis of operant conditioning.[14] His criticism has been aimed primarily at the fragmentation of the material into very small steps and the tone of his comments is not unlike that of cognitive theorists when they discuss the S-R approach to learning. Pressey's alternative to both the Skinnerian and Crowderian programmes is expressed this way:

> In difficult matters such as a science text or industrial or military training manual, bits of autoinstruction may be needed more frequently: each step in the solution of a difficult problem may need such autoelucidation. But the manual or text need not be fragmented into thousands of frames. Problems may be explicated in autoinstructional matter supplementary to the text; and there, or perhaps every 3 or 4 pages in the book, clusters of autoexplicating queries may keep check on understanding. But a book's structural coherence and orderliness of presentation, and its convenience for overview, review, and reference can be kept.[15]

Then, stressing the facility of humans for language, number, silent reading and so on, he advocates that adjunct auto-instruction " . . . keeps, makes uses of and enhances meaningful structure . . . serving to clarify and extend meaningfulness".[16]

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[14]Sydney L. Pressey, "Some Perspectives and Major Problèms Regarding 'Teaching Machines'," in Teaching Machines and Programmed Learning edited by A. A. Lumsdaine and Robert Glaser, (Washington: National Education Association, 1960), pp. 501-502.

[15]Ibid., p. 503.

[16]Sydney L. Pressey, "Teaching Machines (and Learning Theory) Crisis," in Educational Technology edited by John P. DeCecco, (New York: Holt, Rinehart, and Winston, 1964), p. 455.

Figure 47[17] illustrates the adjunct autoinstructional process as Pressey describes it. Box A shows that a student or group of students would be exposed to classroom lectures and demonstration, or text-book assignments or both. After an hour or more of such study, the students leave that activity (arrow 1) and would answer a number of multiple-choice questions (Box B), being informed immediately of their results on each item. They would then return (arrow 2) for more conventional instruction. The dotted line around box B indicates that some learning can take place when self tests are used in isolation from conventional instruction.

It must be noted that in this approach, Pressey assumes that the classroom presentation, books or homework assignment material is in itself so arranged to be conducive to learning. Abma[18] has pointed out that this is a risky assumption to make about conventional materials. It is significant to note that in many reports of applications of

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[17] John S. Abma, Programmed Instruction - Past, Present, Future, A Research Report AMRL-TR-64-89 Prepared for Behavioral Sciences Laboratory, Aerospace Medical Research Laboratories, Aerospace Medical Division, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, (Washington: Department of Commerce, 1964), p. 3.

[18] Ibid.

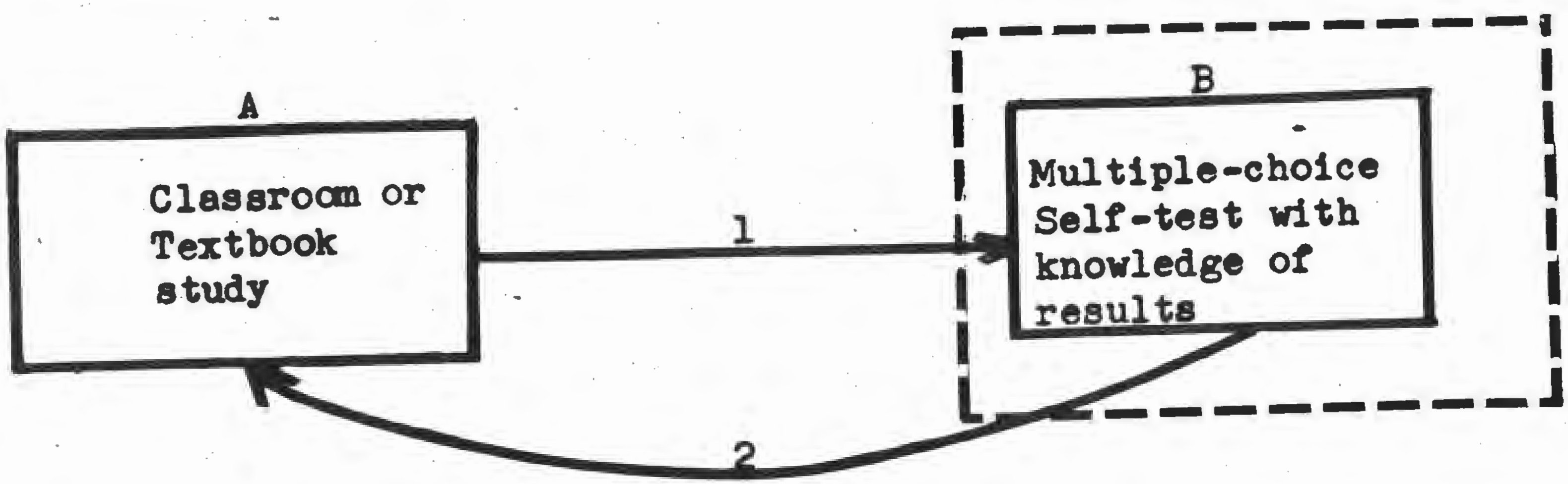

Fig. 47.-- Adjunct Autoinstruction

adjunct programs,[19, 20, 21] the textual material was carefully edited and the response items prepared represented the learning objectives to be attained. In one such project it was reported that the " . . . adjunct program can be less costly to develop and administer and yet produce as much learning as a conventional program . . .. We hypothesize that the student realized that the questions were his objectives and motivated himself to learn them".[22] Mager and Clark also report on the motivational effect of objectives in one of their research projects. They state it this way:

> In the absence of a curriculum generating machine, the adult learner himself might be a better judge of what he needs to add to his current knowledge in order to reach some given set of objectives than is a textbook writer, instructor, or programmer. Given half a chance and a set of reasonable objectives, he will probably generate for himself a curriculum that will

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[19] G. R. Klare, et al., "The Relation of Format Organization to Learning," Educational Research Bulletin XXXVIII (1958), 139-145.

[20] D. E. Meyer, Adjunct to Self-Study for Aircrew Refresher Training, A Research Report prepared for Behavioral Sciences Laboratories Aerospace Medical Research Laboratories, Aerospace Medical Division, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, (Washington: Department of Commerce, 1965).

[21] D. E. Meyer, A Comparison of Response Confirmation Techniques for an Adjunctive Self-Study Program, A Research report prepared for Behavioral Sciences Laboratories, Aerospace Medical Division, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, (Washington: Department of Commerce, 1966).

[22] M. A. Zaccaria and Charles F. Adams, "Adjunct Programming," in Trends in Programmed Instruction edited by Gabriel P. Ofiesh and Wesley C. Meierhenry, (Washington: National Education Association, 1964), p. 180.

lead him to achieve these objectives.[23]

Certain very recent applications of adjunct programming techniques have illustrated the value of such an approach. For example, the U.S. Air Force have just completed validation of a programmed package for the training of Air Force personnel in anti-riot procedures. An integral part of this package consists of two U.S. Army films which were found to be suitable and a series of multiple-choice questions which were developed to direct the student's attention to critical points in the films. Each film is run in its entirety and the questions are answered by the students at the end of the film. This approach has been reported[24] to have met with considerable success even though the films were neither edited nor presented in small "bits". The films had been very well prepared in the first place to meet a well-established requirement and seemed to possess the qualities of "structural coherence and orderliness of presentation" which Pressey mentioned.

The most impressive examples of adjunct programming produced to-date have been those using the Edex presentation - response system. Very carefully planned audio-visual sequences are presented to the class. At critical points in the presentation, response items of various types are

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[23]Robert F. Mager and Cecil Clark, "Exploration in Student-Controlled Instruction," in Trends in Programmed Instruction, Ibid., p. 237.

[24]Interview with Lt. Colonel William A. Strother, Programmed Learning Advisory Service, U.S.A.F. Randolph Air Force Base, Texas, April 15, 1968.

projected and each student responds individually to each item and receives immediate confirmation of his response. Figure 48 shows the equipment designed to implement the program. Each student has a response box electrically connected to the instructor-console. The sound film - film strip - sound tape presentation is automatically controlled by the console and after each section of the presentation is completed, the students are given an opportunity to respond overtly to a response visual using the appropriate response button. Each student's response is recorded and displayed on the console where response meters show the percentage of the group answering A, B, C, or D, and the cumulative scoring counters reflect the progress of each individual. Difficulties are spotted by the instructor and clarification follows before the program proceeds. The USAF driver education program (previously cited) and the program developed by the Bank of America[25] are excellent examples of a well planned, highly co-ordinated instructional adjunct programming technique.

Obviously, the adjunct programme differs from the programmes produced by Skinner and Crowder and their followers. However the success of adjunct programming is credited to the care with which the following procedures, common to all instructional programming, are carried out.

1) Instructional material is carefully planned to

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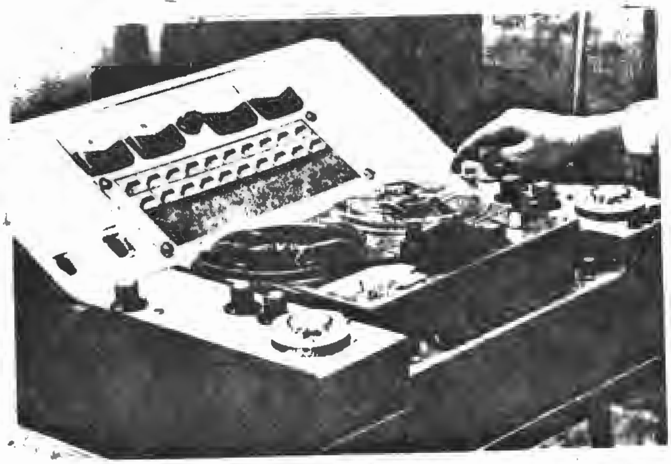
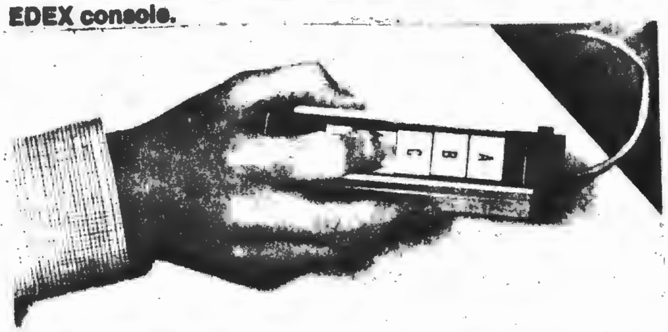
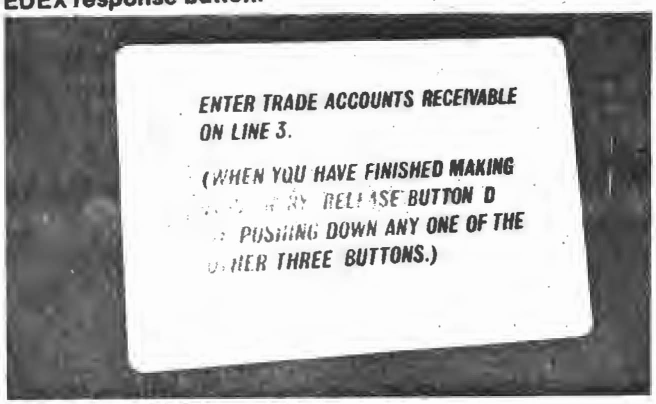
[25]W. D. Robertson, "A Bank Invests in Training Technology," Audiovisual Instruction, XIII (February, 1968), 149-151.



EDEX console.



EDEX response button.



Example of EDEX response visual.

Frame from holdup film *One Chance.*

Fig. 48.--The Edex system

achieve clearly defined behavioural objectives.

2) Students make overt responses at critical points in the instructional material related to the programme objectives.

3) Immediate knowledge of results is provided following student response.

The principal point of difference lies in the amount of material the student is expected to cover (step size) before he makes an overt response.

Adjunct autoinstruction seems to provide a means of ensuring that certain elements of cognitive theory are recognized in the field of instructional technology. It appears to employ principles similar to those of Crowder in the amount of material to be assimilated by the student before the overt response is required and it gives support to the value of providing the student with, a broader approach to the instructional material than Skinnerian programmes do. This approach also offers an opportunity for teachers and trainers to experiment with (1) careful definition of desired behavior with respect to a piece of textual material (e.g. a homework reading assignment); (2) the development of response items to elicit active student response with the material in an effort to ensure achievement of established behavioral objectives; and (3) a validation tryout to see if the programme works.

In the third section of this appendix a form of instructional programming known as Mathetics is described primarily to provide a view of a highly disciplined process which ensures that the programmer/teacher carries out the careful analysis which all forms of programming require but often do not receive.

Mathetics

Mathetics was defined by its founder, Dr. Thomas F. Gilbert, as " . . . the systematic application of reinforcement theory to the analysis and reconstruction of those complex behavior repertoires usually known as 'subject matter mastery', 'knowledge', and 'skill'!"[26]

Harless, a notable follower of Gilbert, has provided a description of Mathetics as it has developed and suggests that it has two distinct meanings:

> First, in its broader implication, mathetics is a complete training system that guides the trainer to description of mastery, and discovery of training deficiencies of a specific population . . .. Mathetics is secondly a step-by-step procedure for the construction of the actual programmed lesson. This process, like other good programming methods, is devoted to ensuring that only the exact functions of the mathetical training unit (the "exercise") are served.[27]

The main interest in this application of operant conditioning is in the manner of analysis which has developed and the technique of using the analysis to develop instructional materials. Considerable change has occurred

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[26]Thomas F. Gilbert, "Mathetics: The Technology of Education," Journal of Mathetics, I (January, 1962), p. 8.

[27]J. H. Harless, "The Two Meanings of Mathetics," Aspects of Educational Technology - The Proceedings of the Programmed Learning Conference, Held at Loughborough, April 15-18, 1966. (London: Methuen & Co., Ltd., 1966), p. 218.

since Gilbert introduced the "technique" so the description which follows is the product of the developmental work of two followers, J. H. Harless and I. K. Davies.

Harless provides the following general procedure for the development of programmed instruction materials.[28]

1) The Analysis Phase, including:
   a) Occupation Analysis in which an occupational domain is analysed into the tasks it contains. See Figure 49.
   b) Task Selection whereby the tasks requiring training are identified using the criteria questions listed in Figure 50.
   c) Analysis of selected tasks to establish criteria of acceptable performance, performance steps, related information that will facilitate performance and any special teaching difficulties. See Figure 51.
   d) Population Analysis whereby the repertoire of the expected students is investigated to determine the skills and knowledge already possessed.
   e) Training Deficiency Analysis in which the difference between (c) and (d) above is determined and designated as the "training deficiency".

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[28] J. H. Harless, "Mathetics: The Ugly Duckling Learns to Fly," National Society for Programmed Instruction Journal, V (July, 1966), 3-5.

OCCUPATION ANALYSIS

Occupation: Service Station Mechanic-Attendant

1. Cleans or replaces spark plugs
2. Adjusts and bleeds brakes
3. Replaces wheel cylinders
4. Inspects and flushes radiator
5. Tests anti-freeze
6. Repairs tire tubes
7. Rotates tires
8. Lubricates vehicles
9. Balances tires
10. Replaces air cleaners
11. Cleans or replaces air filters
12. Washes and waxes autos
13. Sells auto accessories
14. Replaces oil filters
15. Checks oil
16. Washes windshield
17. Fills gas tank
18. Keeps daily records
19. Orders supplies
20. Closes station

Figure 49.

SELECTION CRITERIA QUESTIONS

Phase I: A. Can a majority of these students presently perform this task to a minimal level without training?

B. Do adequate training materials exist that "teach" this task as a unit?

If the answer to either of these questions is "yes", the task is eliminated from further consideration.

Phase II: The remaining tasks are listed and the following questions are weighted and asked of each task.

A. Is the instructor unable to teach this task to an acceptable level with only one group demonstration?

B. Is this a genuine training problem?

C. Are there many stimulus generalizations?

D. Can the behaviours be simulated economically?

E. Is the method for performing this task relatively constant?

F. Will training materials on this task have wide use?

G. Is this a basic learning problem?

H. Is there relatively common agreement on the method of performance of this task?

I. Can training material on this task be economically evaluated?

Figure 50.

TASK ANALYSIS: "Servicing Carburetor Air Cleaners"
(Simplified)

PRODUCT	MINIMUM STANDARDS	STEPS OF PERFORMANCE	RELATED INFORMATION
Cleaned polyurethane Air Cleaner	Time: 10 minutes	1. Unscrew wing nut	Solvent is flammable
	ACCURACY: Free of observable dirt, all solvent drained.	2. Lift off cover	Use kerosene
		3. Remove sponge	Don't smoke
	Completeness: On carburetor with wing nut hand tight.	4. Squeeze in solvent	Sponge tears easily
		5. Squeeze dry	Use pliers
		6. Replace sponge	
		7. Screw air cleaner on with wing nut	

Figure 51.

2) Development of Training Objectives and Criteria Examination. The training deficiency is expressed in terms of training objectives of the Mager-type (as described in Chapter III) and an evaluation made.

3) Development of a Prescription. With the job and population analysis and objectives as guides, the matheticist writes a "prescription" for the training deficiency. The prescription is expressed in stimulus - response units called "operants". This behavioral blueprint identifies the chain and subchains of the behavior and all the discriminations the student must make. The prescription precisely defines the discriminative stimuli and the responses they occasion. Figure 52, illustrates a simplified prescription.

4) Development of Teaching Strategy. This stage is devoted to an analysis of the operants of the prescription in order to discover combinations such as chains, multiple discriminations and generalizations as illustrated in Figure 53. Davies[29] has developed a unique matrix system whereby sequencing of instructional material is based on relationships between discriminations and general-

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[29] I. K. Davies, Mathetics - An Experimental Approach, Report prepared for Headquarters Technical Training Command, Royal Air Force, (Brampton, England, 1967), pp. 5-7. (mimeographed). Figures 53, 54, 55 and 57 have been reproduced from this report.

Prescription: "Servicing Carburetor Air Cleaners"
(Simplified)

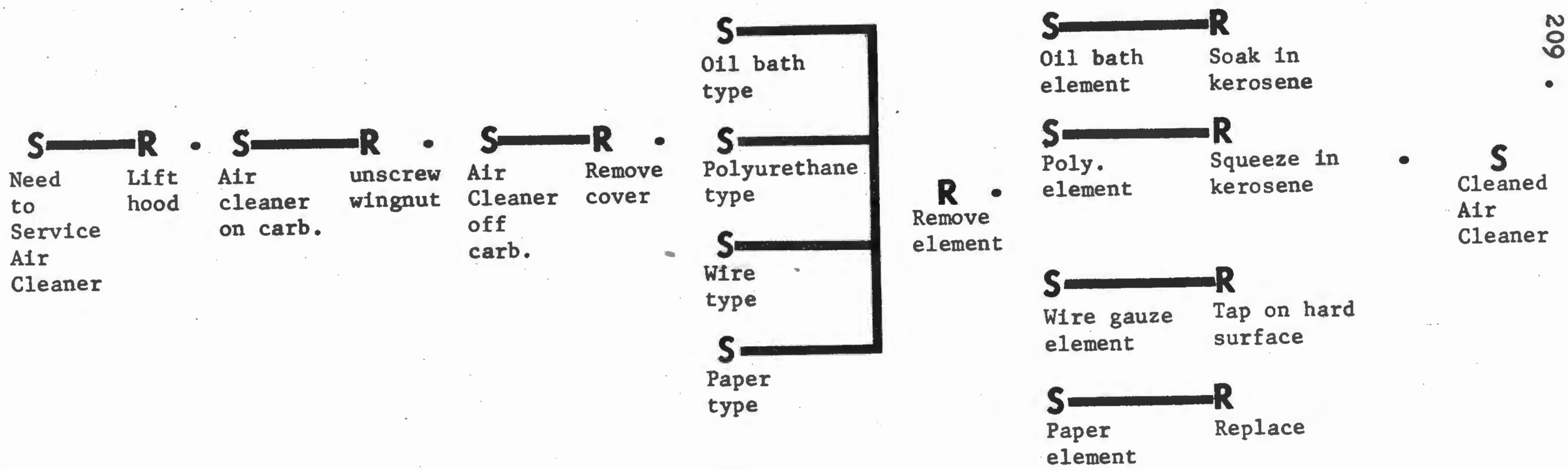


Figure 52.

common stimulus - response patterns

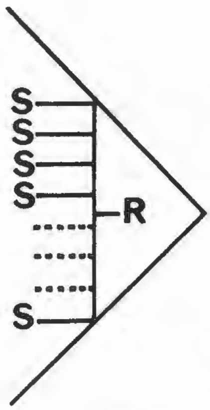
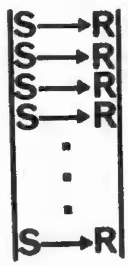
Pattern	Notation	Definition
CHAIN	S→R.S→R.S.....R	An initial stimulus triggers the first response, which then becomes the stimulus for the second response and so on until the final response. In the chain the sequence of stimuli and responses is fixed. One situation causes an event which creates conditions leading to another, and so on to the final event.
GENERALISATION		A situation or event produces two or more stimuli whose <u>combined</u> effect produces a response. One stimulus may be more influential than the others, but all stimuli converge or generalise to one result. The ability to generalise is closely related to the ability to discriminate
MULTIPLE DISCRIMINATION		A situation produces two or more stimuli, each leading to a different response. Each response is related to a common theme, and the discrimination exists in the the ability to distinguish one category of phenomena from another.

Figure 53.

izations as concept development occurs. Figures 54 and 55 illustrate the representative matrix patterns and the teaching action to be taken. In a recent text[30], Davies has provided a comprehensive treatment of the use of these matrices in developing teaching strategies.

5) Development of Lesson Plans and Exercises. The matheticist lists the operants in the sequence he had decided to teach them. This lesson plan is written consistent with the philosophy of the "exercise model" whereby each operant is demonstrated to the student in one exercise, prompted to performance in a second, and released to perform the operant without cues in a third. It should be noted that all operants are released for performance by the students in their correct sequence at least once. A sample mathetics exercise illustrating a discrimination pattern is provided in Figure 56.[31]

6) Try-out and Revision. Figure 57 illustrates a representative sequence of events followed in the production of a mathetics programme as suggested by Davies.

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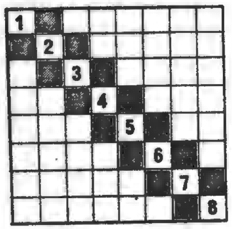
[30] C. A. Thomas, I. K. Davies, D. Openshaw and J. Bird, Programmed Learning in Perspective: A Guide to Program Writing (Chicago: Aldine Publishing Co., 1964).

[31] J. H. Harless, "Mathetics: The Ugly Duckling Learns to Fly," op. cit., pp. 3-5. Figures 49, 50, 51, 52 and 56 have been reproduced from this paper.

basic matrix patterns

1 SIMPLE CHAIN



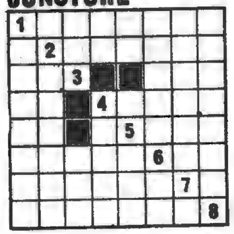
MEANING

The elements are all related through each other: the response to the first stimulus acts as a stimulus to the second response

Action

Teach as a chain of related elements, demonstrating fixed sequence of cause and effect. Consider possibility of teaching chain retrogressively.

3 DISCRIMINATION JUNCTURE



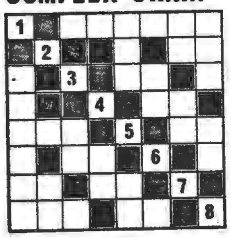
MEANING

Two or more rules have a relationship based upon the ability to distinguish one category from another.

Action

Teach as discriminations, possibly together within one teaching presention.

2 COMPLEX CHAIN



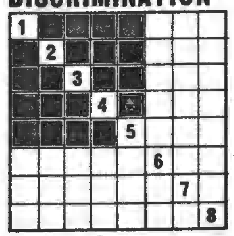
MEANING

Two chains, one of associations and the other of discriminations, diverge from a common point and run parallel with each other demonstrating two logical sequences of relationships.

Action

Teach as separate or parallel chains once discrimination is established. Sequence within chains fixed.

4 MULTIPLE DISCRIMINATION



MEANING

A series of rules bound together by a strong bond of association, have essential differences established through one specific category of phenomena

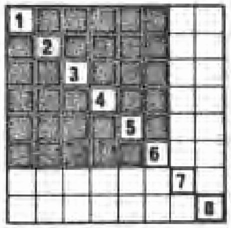
Action

Teach as discriminations possibly established together within one presentation.

Figure 54.

basic matrix patterns (Cont'd)

5 SIMPLE CONCEPT



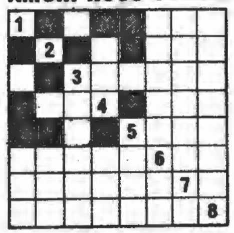
MEANING

A series of rules strongly related to each other by association on the basis of a critical element that they have in common

Action

Establish components, pattern and inter- relationships. Discriminate from similar concepts.

6 AMORPHOUS CONCEPT



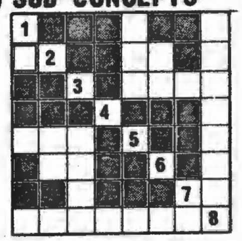
MEANING

A series of rules loosely bound together on the basis of a general element that they have in common

Action

Establish a strong pattern and then discriminate from stronger and weaker concepts.

7 SUB-CONCEPTS



MEANING

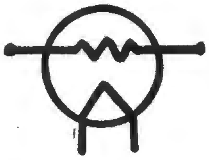
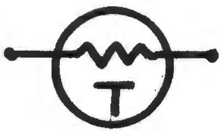
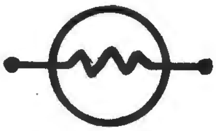
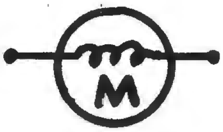
Two or more strongly related concepts, which are bound together via isolate relationships into one primary concept critical to the overlying theme.

Action

Establish either as separate concepts or as parallel concepts before teaching primary concept. Discriminate one with the other, before discrimination from similar concepts.

Figure 55.

When reading a CIRCUIT DIAGRAM, you will find some symbols that look very much alike.

SYMBOL	NAME
	THERMISTOR
	THERMISTOR
	CIRCUIT ELEMENT
	MOTOR

Show what to look for to tell the difference.

1. If the symbol has  or  , what is it? ______________________________

2. If the symbol has  only , what is it? ______________________________

3. If the symbol has  , what is it ?

____

Fig. 56.--A sample mathetics exercise

Program Production Sequence

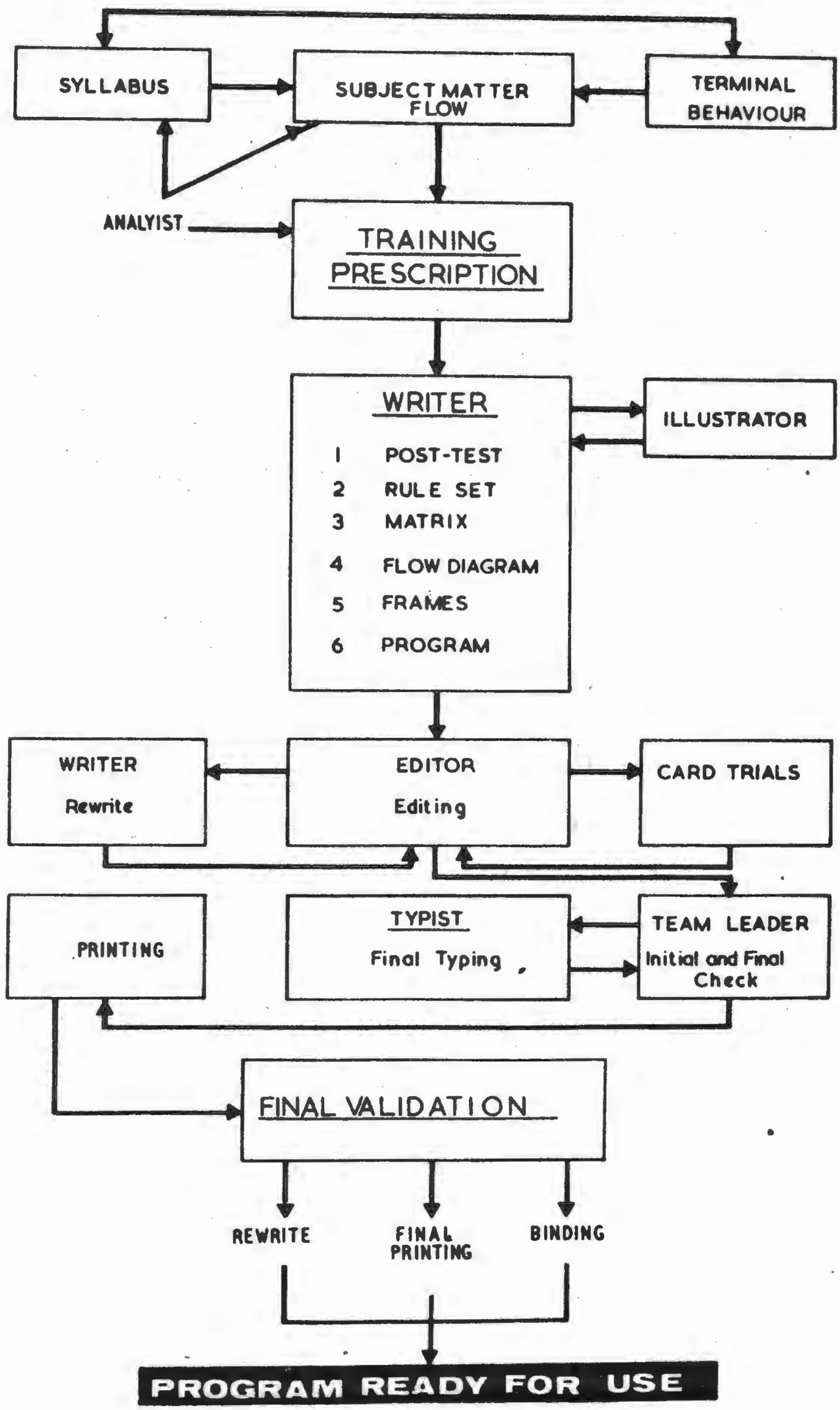


Figure 57

Harless suggests that the mathetical lesson and the linear programme of the Skinner type differ in many respects. The principal differences can be summarized as follows:

1) The mathetical exercise usually encompasses a double-page spread but may be several pages long. An exercise represents the largest amount of behavior a student can absorb in one demonstration. (Optimum operant span). Frame size as demonstrated by Skinner cannot be compared with the mathetical exercise.
2) A mathetical lesson is usually accompanied by an answer book, but not all responses are confirmed.
3) The matheticist makes a special effort to simulate the behaviors he wants, graphically; therefore the lesson is usually highly illustrated.
4) The mathetical lessons are characteristically small in bulk due to the increased operant span and the philosophy of greatly delimited domain achieved by removal of unnecessary material.
5) The matheticist is wedded to his stringent requirement for analysis. Harless suggests that "many programmers profess to perform 'behavioral analysis'; usually, a close examination reveals that even the most sophisticated are merely listing generalizations and discriminations."[32]

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[32] Ibid., p. 6

Mathetics, as a programming process, has been included in this appendix because it illustrates a very carefully worked out procedure for the analysis which behavioral-shaping requires. The degree of analysis which the matheticist declared necessary from the beginning is now being found worthy for any effort or strategy where well-defined behavioral objectives are to be achieved.

Papers by McKee,[33] Pennington,[34] Davies,[35] and Lincoln[36] provide further elaboration on the production and use of mathetical programming in several training areas, while Evans[37] _et. al._ have also developed a disciplined process for developing programmed sequences which employs a matrix and is worth reading.

The examples discussed so far have served to illustrate relatively minor modifications to the principal

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[33]John McKee, "Mathetics and Training of the Disadvantages," Paper read at the Fifth Annual Convention of the National Society of Programmed Instruction, Boston, April 19, 1967.

[34]Dempsey Pennington, "Mathetics in Business and Industry," Paper read at the Fifth Annual Convention of the National Society for Programmed Instruction, Boston, April 19, 1967.

[35]I. K. Davies, _The Halton Experiment: Interim Report_ prepared for the Research Branch, Headquarters Technical Training Command, Royal Air Force, Brampton, England, November, 1964. (Mimeographed).

[36]Richard Lincoln, "Mathetics and Medical - Related Training," Paper read at the Fifth Annual Convention of the National Society for Programmed Instruction, Boston, April 19, 1967.

[37]James L. Evans, Lloyd Homme and Robert Glasser, "The Ruleg System for the Construction of Programmed Verbal Learning Sequences," _Journal of Educational Research,_ IV (June-July, 1962), 513-518.

applications of Programmed Learning which have appeared since Skinner produced his first programme. The most recent development in the field of instructional programming, however, involves the use of the computer and promises to be the most revoluntionary of all. The common name applied to this evolving form is Computer-Assisted Instruction (C.A.I.) though it is referred to by some writers as Adaptive Programming due to its ability to adapt to student responses. A brief description of this technique follows in the final section of the appendix.

Computer-Assisted Instruction

In a discussion of the effects of the computer on society, General David Sarnoff had this to say with respect to education.

> Some of the most profound changes wrought by the computer will be in education. Here, the machine will do more than assist students to solve problems and to locate up-to-date information. It will fundamentally improve and enrich the entire learning process. The student's educational experience will be analyzed by the computer from the primary grades through university. Computer-based teaching machines programmed and operated by teachers thoroughly trained in electronic data processing techniques, will instruct students at the rate best suited to each individual. The concept of mass education will give way to the concept of personal tutoring, with the teacher and the computer working as a team. [Italics mine] Computers will bring many new learning dimensions to the classroom. For example, they will simulate nuclear reactors and other complex dangerous, or remote systems, enabling students to learn through a form of experience that could formerly be taught only in theory.[38]

[38]David Sarnoff, "No Life Untouched," Saturday Review, July 23, 1966, pp. 21-22.

Since 1955 three major stages in the application of computer technology to education have been evident. The installation of the university computing centre for the solution of mathematical and scientific problems came first. The second stage involved the use of electronic data-processing systems in accounting, record keeping, and logistical control activities. The third stage, now barely under way, involves the use of computers with teletypes and cathode-ray tube display equipment for supporting educators and learners in a wide range of intellectual processes. It is this application that " . . . spells a revolution in American education."[39]

The relationship of Computer Assisted Instruction to its predecessor, Programmed Instruction, has been expressed by Silvern as follows:

> If instruction is provided without the presence or intervention of a human instructor, then it may be called programmed instruction. However, if a computer is utilized instead of (not in place of) a programmed text or simple teaching machine, then the computer is assisting the instructional process -- and the new process may be called "computer-assisted instruction".[40]

The true nature of C.A.I. can best be understood if

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[39]Donald D. Bushnell, "Applications of Computer Technology to the Improvement of Learning," in <u>The Computer in American Education</u> edited by Donald D. Bushnell and Dwight W. Allen (New York: John Wiley and Sons, Inc., 1967), p. 73.

[40]Leonard C. Silvern, "Programmed Instruction and Computer-Assisted Instruction - How They Can Be Used in Our Training Programs," in the <u>Conference Proceedings of the Third International Simulation and Training Conference of the Society of Automotive Engineers, Inc., New York</u>, April 24-27, 1967., pp. 81-102.

one deals with it in terms of the student-computer interface characteristics. To begin with C.A.I. is clearly learner-centered. The learner communicates with and receives communication from the computers remote console, usually consisting of printer-keyboards or teleprinters. The trainee sits at his teleprinter and performs two functions: he reads what is typed on the printout, and he types responses, questions and other verbal inputs on his keyboard for transmission to the computer. Not stated, but understood, is a third function: conceptualizing the response through a mental, covert activity.

In a discussion of the use of computers in instruction, Suppes[41] has described 3 levels of interaction between the student and the computer program in C.A.I. They are outlined as follows:

1) Drill-and-practice systems which provide a simple, straight-forward, and individualized approach intended to relieve the teacher/instructor of a considerable burden and at the same time take a substantial step toward providing practice work at a level appropriate to each student. This is more sophisticated than it appears as the computer is able to channel the student's activity in areas dependent on his performance level and produce

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[41]Patrick Suppes, "Plug-In Instruction", Saturday Review, July 23, 1966, pp. 29-30.

a complete record of student progress and problems areas for teacher's use.

2) Tutorial systems which have as their aim to take over the main responsibility for developing skill in the use of a given concept. In this mode, it is now possible to approximate the interaction a tutor would have with a student and to analyze each student's comprehension in greater depth and detail than is usually possible for a teacher of thirty students in a conventional classroom.

3) Dialogue systems which are envisaged as capable of conducting a genuine dialogue with the student and the program. Such systems exist now only as prototypes and are not expected to be perfected for some time to come.

The advantages of such systems have been expressed by Louis Hausman, assistant to the Commissioner of the U.S. Office of Education, and can be summarized in the following manner.

1) The machine never gets tired. It can repeat as often as necessary without losing its temper or needing a rest.

2) It is a private system in which the individual proceeds at his own pace. The slower learners are not embarrassed in front of their quicker peers; the more academically gifted do not get bored by a pace directed at the median student.

3) The system in which a student is frozen at the certain level for a whole or half term is replaced by a daily tracking system, in which a student moves up or down each day after each lesson.

4) It permits scientific development of a curriculum by learned societies and teachers. This can have wide applicability; even small rural schools in poverty areas could compete with large suburban schools in breadth of courses available as well as level of competence.

5) It ensures the acquisition of basic skills for children of educationally deprived backgrounds and makes them more teachable as they progress.

6) It provides a complete, instantly available record of each child's achievement and furnishes information for course modification.[42]

Hausman reiterates the point that teachers will not be pushed aside by such systems. He states, rather, that the systems will " . . . emancipate teachers and restore them to the dignity and fulfilment which is integral to their function".[43] This is reminiscent of similar comments made by Pressey and Skinner (previously cited) many years ago as they expressed their support for a technology of instruction.

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[42] Louis Hausman, "The ABC's of CAI", American Education, XII (November, 1967), 15.

[43] Ibid.

In CAI it would seem that the teacher/instructor becomes a manager of the training process. He evaluates and counsels trainees with the help of reports from the computer, and he provides special and remedial instruction. He is elevated from the present position of communicator to that of directing communications. However, just as a classroom teacher or instructor is rarely the author of the textbook or manual his trainees use, he will rarely be the author of the CAI programme.

The instructional programmer (lesson planner or author) is responsible for developing the instructional programme. The developmental steps normally taken are as follows:

1) Perform a job and task analysis.
2) Establish behavioral objectives.
3) Devise criterion tests which measure achievement of objectives.
4) Develop course outline.
5) Write steps in Lesson Plan.
6) Evaluate, revise and validate.[44]

The similarity of this sequence of activities to the programming as well as the system procedural process is obvious.

It has not been possible to provide a detailed description of CAI in this appendix. The computer itself is a relatively new device and time-sharing, which makes CAI

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[44] Silvern, op. cit., p. 87.

economically feasible, is being applied on a large scale only in industry. However several research projects are being progressed in schools and universities on a limited scale. Four typical on-going projects will be briefly described for reference purposes.

The Miller Grove Project. In the Miller Grove School Section in Philadelphia a CAI project was established to teach reading and biology. The School District set the curriculum requirements and programs were prepared for the four small computers being used. Dr. Sylvia Charp, Director of Instructional Systems in Philadelphia in a recent report[45] indicated that the project was receiving its best response from poor students. She attributed this to the lack of teacher or peer group pressure and the reinforcement the program provided in CAI.

She suggested that staff development is still a major problem which is being met by in-service courses and summer school programs. During the question period Dr. Charp indicated that a public school system that is considering CAI can attempt it either by acquiring a small computer or through time-sharing. She stated that if time-sharing is to be the answer, manufacturers of the terminal equipment will have to reduce the cost. There was a heated discussion of who should write the CAI materials. Dr. Charp

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[45] Sylvia Charp, "CAI in Philadelphia Schools," Paper read at the Third Annual Conference on Education and Training sponsored by the American Management Association, New York, August 8-11, 1967.

maintained that the educator should write all the material with the hardware manufacturer, technical specialist and publisher serving as advisors.

Florida State University Project. In the fall of 1967, 30 Florida State University students began to receive all their instruction at the CAI center where an extensive array of review and problem types of presentation in physics and chemistry have been developed. Duncan N. Hansen, Director of the Centre, stated that "when you schedule this kind of activity, the assumptions about the normal 40-hour week fixed program are not compatible with students desires. They like to take this instruction on Sunday or between 7 and 11 P.M."[46] In the same report he quoted some interesting figures on the cost of providing an evaluation service for a junior high school science curriculum for Grade 1 through 9. He said that readapting 29 chapters representing 180 hours of instruction cost $8000 coding cost $4000, and the total development cost was $14,610 for the year or $81.19 per instructional hour.

In commenting on the future of CAI,[47] Dr. Hansen suggests that Florida students could take courses from New York professors once CAI courses can be transmitted across

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[46]Duncan Hansen, "Education in Real Time for the Computer Age," Paper read at the Third Annual Conference on Education and Training sponsored by the American Management Association, New York, August 8-11, 1967.

[47]"The Versatile Computer is a Counselor, Planner, Patient, Professor, Tutor and Paper Pusher," American Education, III (November, 1967), p. 19.

the continent by cable. He also points out that professors could teach large classes of a hundred or more on an individual tutoring basis, for the hours currently devoted to lecturing groups could then be turned to helping students in small group discussion sessions.

The Brentwood School Project.[48] Under the direction of Professors Richard C. Atkinson and Patrick Suppes, 100 youngsters entered the first grade in Brentwood School in East Palo Alto, California and began to learn to read and to work arithmetic by means of CAI. The results, though incomplete, are extremely promising. Those pupils who had been taught reading by a combination of computer and classroom teacher were several months ahead of their peers in reading ability. They achieved higher marks in the recognition and pronunciation of words, phonetics, and in vocabulary. Paragraph comprehension was the only skill in which they were not superior and the difference was slight. The students spent only 20 minutes a day at the computer.

The project is only a year old and more concrete evidence is expected during the 1967-68 academic year.

Student Controlled CAI.[49] Ralph E. Grubb in a recent CAI seminar at the Sixth Annual Convention of the National Society for Programmed Instruction, described a

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[48]Ibid., p. 20.

[49]Ralph E. Grubb, "Introduction to CAI," Paper presented at the Sixth Annual Convention of the National Society for Programmed Instruction, San Antonia, April 17-20, 1968.

a unique approach to computer-assisted instruction that puts the student rather than the computer in control. Images projected on a screen display a series of "roadmaps" of the statistics course being taught. The maps are a series of interconnected boxes inscribed with topics or concepts through which the student routes his way by pointing a light pen at the area that interests him. Then his screen is erased and he is confronted with a more detailed sub-map and so on through successive phases. When he wishes to receive detailed information on a particular point in any sub-map, he may query the computer. He is then led through a teaching sequence.

Grubb stated that an advantage of the new approach over linear programs, was that the student bears primary responsibility for the nature and sequences of topics in his course. He is motivated by the fact that he is not involved in a given section unless he choose to be there. Throughout the process, he is confronted with both structure and content simultaneously. Most self-instruction courses fragment the subject into small steps and the student never "sees the course for the frames". Such a failure becomes virtually impossible under this instruction method, as the maps show him how one part relates to another.

While the above examples of CAI applications have been sketchy due to the lack of detailed information on these projects, they serve to illustrate the scope of CAI in education and training and provide some indication of the expectations for this development in the future. Further indications of the interest which CAI has engendered can be seen in Tables 4 and 5 which list the funded research being supported by U.S. Federal education agencies.[50] This does not include the extensive research and development being carried on by the U.S. Armed Forces and civilian agencies in the field of CAI.

Computer-Assisted Instruction offers tremendous scope for research in and application of learning theory. Those who might wish to study the development of CAI in greater detail would do well to start with the comprehensive literature survey by Hickey and Newton[51] which reviews 242 documents related to CAI under the following headings.

1) Reviews and Bibliographies
2) Applications
3) CAI Centres
4) CAI Systems Studies
5) List of Developed CAI Programmes - 140 in number.

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[50] "Computers in Education", American Education, III (November, 1967), pp. 24-25. Tables 4 and 5 have been extracted from this article and included here for ready reference.

[51] Albert E. Hickey and Jack M. Newton, "Computer Assisted Instruction - A Survey of the Literature-Second Edition, January, 1957, (Newburyport, Massachusetts: Entelek Inc., 1967).

TABLE 4

Computer-related projects under title VI, National Defense Education Act of 1958

Investigator/institution	Subject	Grant (FY 67)
Patrick Suppes Stanford U.	Analysis of second-language learning with emphasis on Russian	$159,647 ('66)
Joseph A. Van Campen Stanford U.	Supplemental materials for computer-based first-year course in Russian	104,425
William H. Clark U. of Rochester	Programed foreign language courses in secondary school with specially trained teachers	11,006
Catherine J. Garvey	Developmental testing of a self-instructional French course	64,235
Frederick W. Mote Princeton U.	Research on Chinese linguistics (first of two conferences to aid National East Asian linguistics project)	11,000

Computer-related projects under title IV, Elementary and Secondary Education Act of 1965 and title VII, the National Defense Education Act of 1958 [1]

Category	Number of active projects	Average project cost	Total cost [2]
Computer-assisted instruction	23	$278,563	$6,406,893
Programing for specialized data development and analysis	6	33,588	201,529
Computer models and simulation	5	56,353	281,653
Data banks and information retrieval system	4	183,561	734,347
Computers in administration and organization	13	35,002	455,023
Curriculum and training for computer application	9	40,205	361,847
Totals	60	140,688	8,441,292

[1] Not including research and related activities of the research and development centers and regional educational laboratories, or the ERIC program.
[2] Many projects extend over several years and receive funds in phases, involving funds from more than one fiscal year.

Computer-related projects under title III, Elementary and Secondary Education Act of 1965

Category [1]	Number of active projects	Average project cost	Total cost
Computer-assisted instruction	35	$102,950	$3,603,264
Programing for specialized data development and analysis	18	149,366	2,688,594
Computer models and simulation	3	168,513	505,539
Data banks and information retrieval system	15	132,678	1,990,165
Computers in administration and organization	18	192,800	3,470,409
Curriculum and training for computer application	23	121,942	2,804,660
Totals	112	134,484	15,062,631

[1] Although the majority of these projects do involve computer-assisted instruction programs, title III projects generally tend to overlap several categories. They have been categorized here by what appears to be the major emphasis of each project.

APPENDIX C

AN APPLICATION OF THE SYSTEMS APPROACH TO TRAINING IN THE CANADIAN ARMED FORCES[1]

Introduction

With the advent of unification of the Armed Services in Canada, considerable change in the structure of the trades within the forces resulted. Some trades were phased out. Others were amalgamated to provide for the most efficient use of available manpower. These changes required that a great deal of attention be focussed on the specifications of all trades and the operational requirements of tradesmen in the field/fleet. Coupled with this renewed interest in trade structure was a fresh look at the state of training of tradesmen in the various school complexes throughout the Armed Forces. This report deals with the current results obtained in a study of training in the Fleet School, Halifax.

Training Rationale

The sole purpose of trade training is to prepare the tradesman to perform the trade jobs required of him. From

[1]The opinions expressed in this appendix are those of the author and do not necessarily represent the position of the Department of National Defence.

the tradesman's point of view this means that he must acquire a repertoire of applicable mental and physical skills during training which will enable him to perform satisfactorily on the job. The trainer's responsibility is to establish an environment in which acquisition of the required skills is not only possible but highly probable. Fulfilment of such a responsibility requires that the skills to be attained be identified and clearly defined. Then, and only then, can an efficient and effective training system be developed.

In the process of experimenting with the development of programmed instructional materials for use in the Electrical Division of the Fleet School, Lieutenant Commander S. L. Morse and the staff of the Programmed Learning Section were greatly encouraged by the success students experienced in the attainment of clearly defined goals through the use of these materials. However in their efforts to determine what behaviour was expected of students after units of instruction, they were appalled at the apparent lack of clearly defined student-oriented objectives. This "fuzziness of purpose" which seemed to be widespread, cast considerable doubt on the validity and relevancy of some of the material being taught and some of the skills being acquired by the tradesmen under training.

At this juncture, (1966) because of the problem of getting clear definition of intent, the staff of the section concentrated on objective development and clarification of specifications of the naval trades as they existed at that time. It is significant that the staff were greatly influenced by the discipline of the programming approach and while a great deal of time was spent away from the production of programs as such, at no time did the staff consider that they had ceased programming.

This concern over the lack of definite training objectives was reported to Training Command Headquarters on several occasions from various sources and in due course, interested Command personnel established the requirement for the development of Training Standards for all levels of all trades in the Canadian Armed Forces.

The training standards were to consist of clearly specified training objectives defining the performances to be achieved by the student at the end of the training period(s). However, the desire for the standards evolved more rapidly than the establishment of appropriate procedures for deriving them. In recognition of the need for carefully designed process and control documents, permission was requested to carry out a pilot study of possible procedures for development of training standards for the Weaponman Underwater (Wpmn U) trade.

Conduct of the Study

The pilot study was approved and the study commenced in April, 1967, under the direction of the Commandant, Fleet School, Halifax, and by the authority of Training Command Headquarters. A Study Team of Chief Petty Officers and Petty Officers of the WPMN U trade was provided by the Officer-in-Charge, Weapons Division, Fleet School Halifax. In the selection of the members of the team, highest priority was given to personnel with current operational experience and at least one previous posting in the training environment. Although a number of changes in personnel have occurred, the senior tradesman of the team has been continuously employed in the project and has provided the much needed continuity. Also, he is the only member who received specialized training in behavioral analysis prior to joining the project. The remaining members have received on-task training under the direction of the staff of the Programmed Learning Section. The study is still in progress and is expected to complete by March, 1969.

Project Aim and Value

The aim of the WPMN U pilot study has been to develop procedures and documentation whereby trade performance requirements will be so expressed and training goals so stated as to produce precise training standards, and documents fundamental to effective training control. The production of such standards and such control documents ensures that the following conditions essential to precise training practice may be established:

1) Trainers and students will be provided with realistic and precise statements of the training standards to be achieved in respect to each

trade job or task.

2) Clear definition of the respective training responsibilities of the on-the-job trainers and formal course trainers will be confirmed.

3) Operational personnel will be able to determine from training standards, the capabilities and limitations of graduate tradesmen whom they employ.

4) Trainers will be able to discern the relationship of each training objective to the job or task for which it is designed.

5) Feed-back on the performance of course graduates can be meaningfully analyzed in terms of jobs and tasks assigned to the particular Trade/Pay Level, in terms of objectives established in the Training Standards, and in terms of training strategy and procedures employed.

Procedures

The critical documents to be developed and the information components of which they consist are portrayed in Figure 58. The Study Team is responsible for the development and production of the Trade Performance Standard and the Trade Training Standard only. Development and production of the remaining documents is the responsibility of the school charged with the requirement to ensure that tradesmen achieve the standards. It should be noted however that the very nature of the process of analysis and synthesis

TRADE TRAINING DOCUMENTS AND COMPONENTS

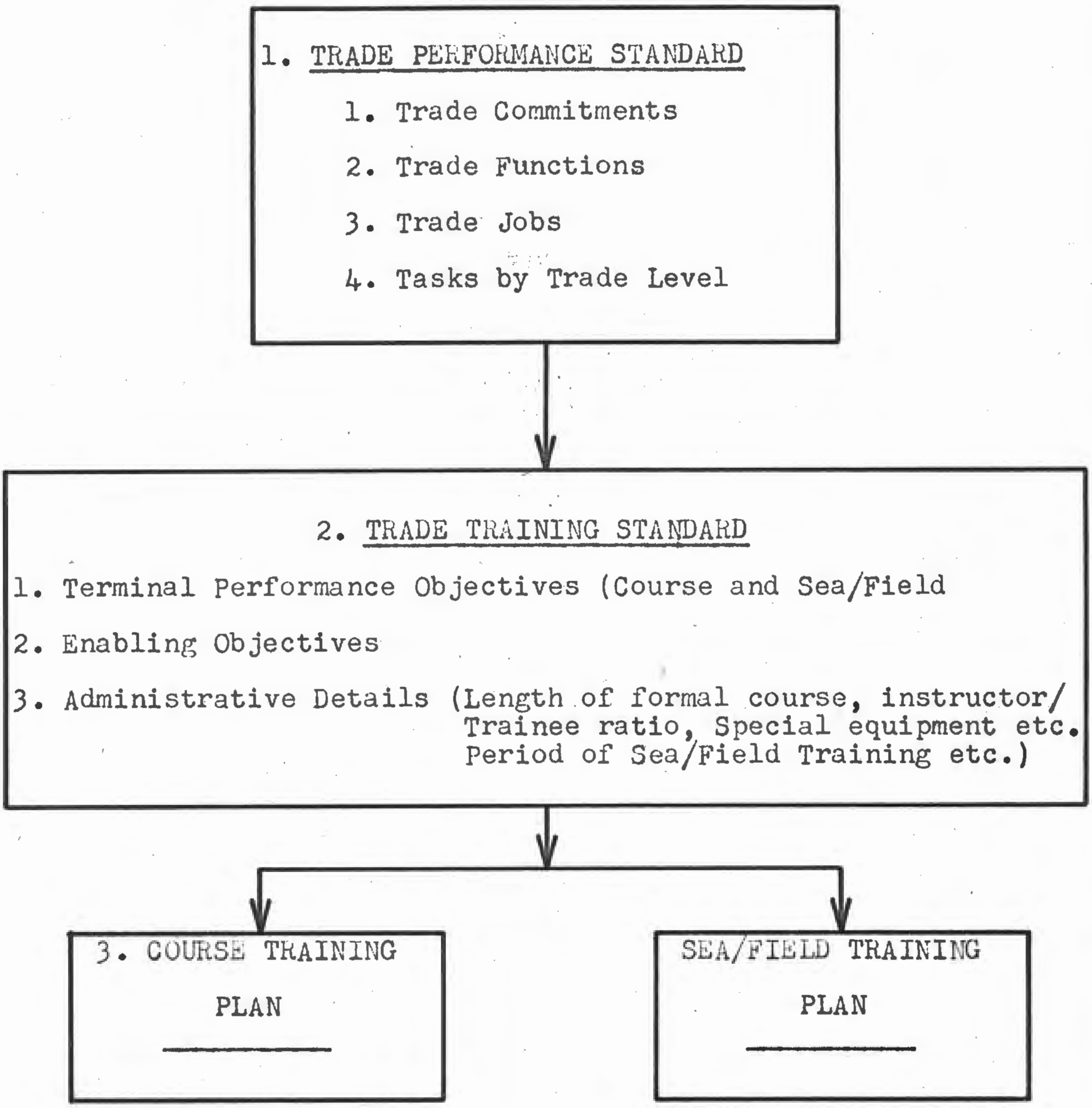

Figure 58.

requires a careful consideration of the interrelationship between the various steps. Figure 59 indicates the sequence in which the documents are being developed.

The Trade Performance Standard was the first document produced during the study. It represents the efforts of the study team to define the tradesman's operational performance requirements by employing a step-by-step analysis starting from the broad requirements of the complete trade down to the definition of the tasks performed by tradesmen at each level within the trade. A description of each step in the procedure, in terms of the information derived, follows:

1) Trade Commitments: - These are statements of the output of the trade. They express what the trade contributes to the fighting or operating capabilities of the ship directly, as well as what the trade does to assist other trades in meeting their requirements. Commitments are designed to be enduring, to define the limits of the trade, and when approved by Operational authority, to constitute the justification for all trade activities required to fulfill them.

2) Trade Functions: - These state, in the case of each Trade Commitment, the functions which are implicit in the commitment. As in the case of the commitments, these are written without reference to particular types of equipment, and thus are designed

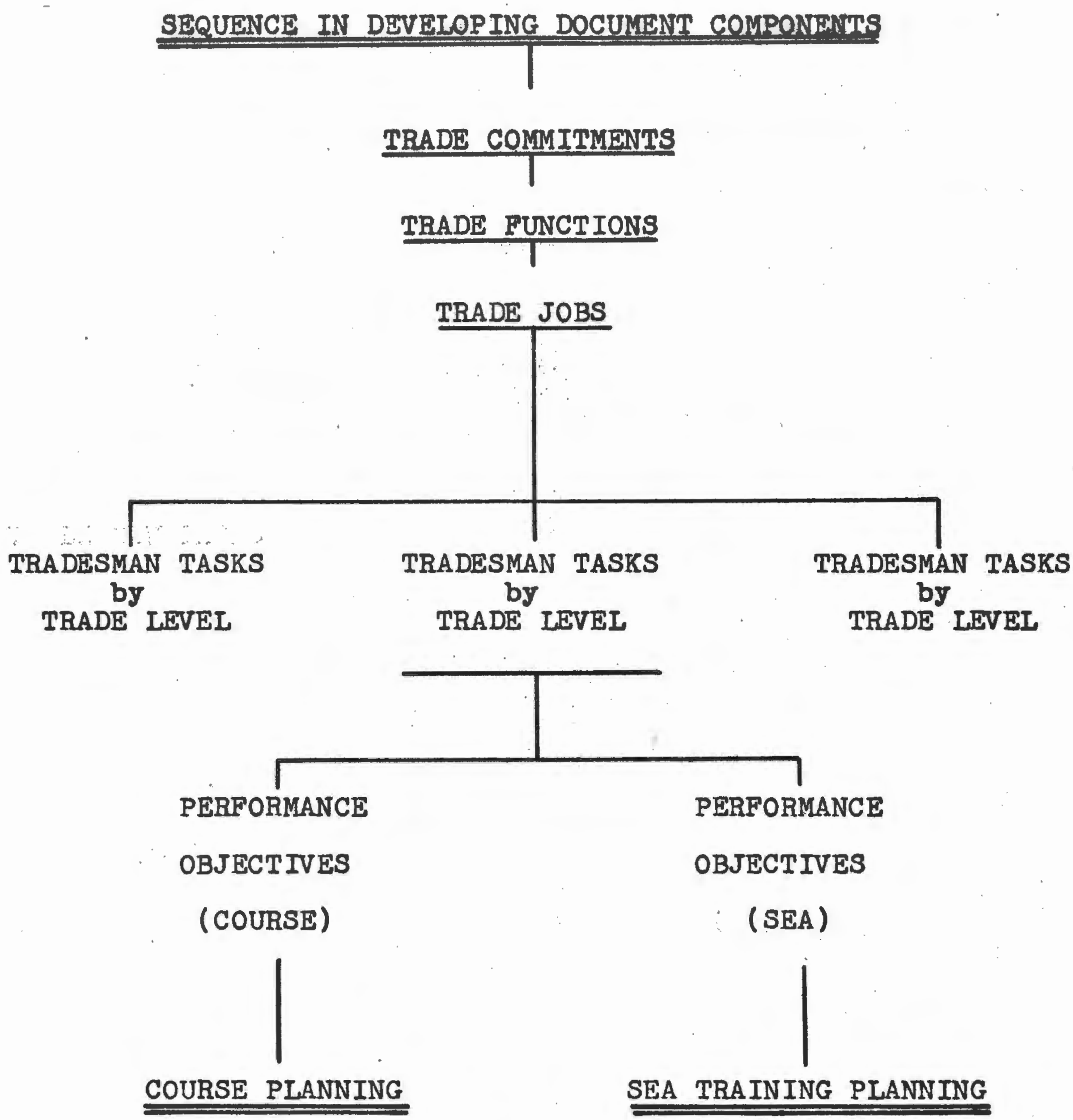
SEQUENCE IN DEVELOPING DOCUMENT COMPONENTS
TRADE COMMITMENTS
TRADE FUNCTIONS
TRADE JOBS
TRADESMAN TASKS by TRADE LEVEL
TRADESMAN TASKS by TRADE LEVEL
TRADESMAN TASKS by TRADE LEVEL
PERFORMANCE OBJECTIVES (COURSE)
PERFORMANCE OBJECTIVES (SEA)
COURSE PLANNING
SEA TRAINING PLANNING

Figure 59.

to be enduring. Wpmn U trade commitments and trade functions are listed in Figure 60.

3) <u>Major Trade Activities:</u> - These are restatements of the generalized functions in terms of specific equipment. Thus the function "To prepare underwater weapons", is restated as "To prepare the A/S Mortar MK NC 10". From this point onward, changes in the Weaponman's equipment will necessitate amendments to the Trade Performance Standards.

4) <u>Trade Jobs</u>: - These are the units of work which constitute the Major Trade Activities. Each unit of work, or job, is recognized as a series of actions which normally occur together and which interact in some characteristic manner. Performance of any Job may lie within the capabilities of an individual, or may require group effort. The numbers of personnel involved is not a criterion in establishing Trade Jobs.

5) <u>Trade Tasks</u>: - These are a breakdown of Trade Jobs into activities which can be performed by an individual, and hence, are assignable to individual tradesmen. Figures 61 and 62 provide examples of jobs and tasks contained within one of the Major Trade Activities.

At this point it was realized that a further analysis of the nature of each task was required before the next steps in the procedure could be taken. A description

TRADE: WEAPONMAN UNDERWATER DATE: 23 June, 1967

FUNCTION REFERENCE	MAJOR TRADE ACTIVITIES	TRADE JOBS & ASSIGNED PAY LEVELS		TRADE TASKS & ASSIGNED PAY LEVELS	
1.1	.1 Performs preparation loading and firing procedures on A/S Mortar MK N.C. 10 and associated equipment.	a. Prepares breeches and barrels for firing.		(1) Sponges out barrels and cartridge containers.	3
				(2) Cleans, examines for corrosion and oils breeches.	3
				(3) Lubricates and hand-operates range valves.	3
				(4) Checks that calibration plugs are clear.	3
				(5) For light projectile firings, inserts cartridge container liners.	4
		b. Performs operational checks and tests on Sonar Control Transmissions.		(1) Checks alignment of trajectory bearing indicator dials.	5
				(2) Checks range valve alignment with transmitted signal.	5
				(3) Checks alignment of mortar with transmitted signals.	5
		c. Performs operational checks and tests on Local/Remote depth-Setting circuits.		(1) Locally tests individual barrel depth-setting circuits of the depth-setting control panel.	5
				(2) Locally tests individual barrel fuse-homing circuits of the depth-setting control panel.	5
				(3) Checks remote depth-setting circuits.	5
		d. Performs operational checks and tests on firing circuits.		(1) Locally tests for continuity of firing circuits.	5
				(2) Locally tests firing circuits for proper insulation.	
				(3) Carries out Local/Remote single/salvo lamp test.	5
		e. Performs operational checks and tests on mounting through full limits of operation.		(1) Checks correct operation of quadrant elevation switch.	4
				(2) Checks correct operation of Roll and Pitch limit switches.	6
				(3) Checks correct operation of safety switch unit.	5

Fig. 60.--Trade commitments and functions

TRADE: WEAPONMAN UNDERWATER

TRADE COMMITMENTS	TRADE FUNCTIONS
1. The trade maintains the shipboard capability to deliver destructive devices on submerged targets to the extent of readying launchers, firing under specified conditions, stowing and handling propellants and underwater explosives and maintaining the electrical, mechanical, hydraulic and pneumatic components of underwater weapons and associated equipment.	.1 Prepares, loads and fires underwater weapons. .2 Performs shipboard maintenance and trials of underwater weapons equipment. .3 Stows and handles underwater propellants and explosives. .4 Performs departmental administration for required supply and control.
2. The trade maintains the shipboard capacity to detect and counter underwater threats to the ship to the extent of operating and maintaining electrical, mechanical, hydraulic and pneumatic components of submarine-detection launching and recovery devices, and torpedo countermeasure devices and streaming/recovery gear.	.1 Launches and recovers submarine-detection devices. .2 Maintains and trials launching and recovery gear for submarine detection devices. .3 Streams and recovers torpedo countermeasures devices. .4 Performs shipboard maintenance and trials of torpedo countermeasures and countermeasure streaming/recovery gear. .5 Performs departmental administration for required supply and control.
3. The trade assists the sonar trade in their training programme by launching, recovering and preserving anti-submarine mobile targets and stowing and arming of underwater explosive signalling devices.	.1 Launches and recovers anti-submarine mobile targets. .2 Provides maintenance for care and preservation of anti-submarine mobile targets. .3 Stows and arms grenades. .4 Performs departmental administration for required supply and control.
4. The trade contributes to the ship's ability to destroy targets afloat and ashore by stowing, handling, fitting, placing and detonating above water demolition charges.	.1 Handles and stows above-water demolitions. .2 Performs above-water demolitions. .3 Performs departmental administration for required supply and control.
5. The Trade improves the capabilities of underwater weapons and associated equipment by carrying out ships' staff electrical, mechanical, hydraulic and pneumatic modifications and by co-ordinating and verifying that installations and modifications by repair facilities or contract are in accordance with specifications.	.1 Performs ships staff modifications, requests repair facility assistance for repair facility classification modifications and verifies and records their satisfactory completion. .2 Determines and reports to authority the degree to which installations by contract meet specifications.

Fig. 61.--Trade jobs and tasks (1)

TRADE: WEAPONMAN UNDERWATER   DATE: 23 June, 1967

FUNCTION REFERENCE	MAJOR TRADE ACTIVITIES	TRADE JOBS & ASSIGNED PAY LEVELS		TRADE TASKS & ASSIGNED PAY LEVELS	
	.1 Performs preparation Loading and Firing procedures on A/S Mortar MK NC 10 and associated equipment.	k. Loads Mortar MK NC 10 projectiles under emergency conditions.		(1) Operates rack selector mechanism.	3
				(2) Operates rack discharge arms.	3
				(3) Operates trap mechanism.	3
				(4) Operates hoist manually.	4
				(5) Operates conveyers manually.	4
				(6) Operates Rammers manually.	4
		l. Loads Mortar MK N.C. 10 Impulse Cartridges.		(1) Operates breech mechanism.	3
				(2) Inserts appropriate impulse cartridge into breech.	3
		m. Maintains firing under Normal (N) and Emergency (E) conditions.		(1) Operates emergency stop position on mountings.(E)	3
				(2) Operates breech mechanism. (N/E)	3
				(3) Loads impulse cartridges. (N/E)	3
				(4) Hand trains mounting. (E)	3
				(5) Hand sets range. (E)	3
				(6) Operates mounting control switch. (E)	3
				(7) Operates master control panel. (N)	4
				(8) Operates hoist conveyer, rammers in power (N).	4
				(9) Operates hoist, conveyer and rammers in hand. (E)	4
				(10) Operates rack selector. (N/E)	3
				(11) Operates trap mechanism. (N/E)	3
				(12) Operates discharge arms. (N/E)	3
				(13) Operates normal/emergency switch on charging and distribution panel. (E)	3
				(14) Operates emergency stop push in handling room. (E)	3
				(15) Operates weapons control panel. (N/E)	5
				(16) Operates depth setting control panel. (N/E)	5
				(17) Operates misfire switch. (E)	5
				(18) Maintains essential voice communication (N/E)	4
				(19) Operates 60V reset push button switch. (N)	4

Fig. 62.--Trade jobs and tasks (2)

of each trade task was prepared providing a list of references, materials and tools together with statements of the steps involved (what to do), the activities involved in performing each step (how to do it), and key points to be considered. Figures 63, 64 and 65 provide examples of the Job/Task descriptions. While some of these were quite simple in content, others were considerably more complex. These descriptions were required for the following processes:

1) <u>Allocation of tasks by Pay Level</u>:[2] - For many tasks, it has been necessary to refer to the job descriptions to determine the complexity of the task, in order to make a realistic allocation by Pay Level. When Job Descriptions, from the standpoint of directing or supervising, are developed, it is considered that they will be equally necessary in allocating jobs by Pay Level.

2) <u>Preparation of Valid Training Standard Objectives</u>: - Job/Task descriptions contain the procedures for performing jobs and tasks, together with key points. They are essential in preparing valid Training Standards Objectives.

3) <u>Course Design</u>: - The Job/Task Descriptions provide essential information to the school in determining precisely the behaviors which trainees are to

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[2] Armed Forces tradesmen are classified by Pay Levels One to Eight. Pay Level 1 is the new entry level while pay level 8 designates the most senior tradesman. (Chief Warrant Officer).

T. P. S. REFERENCE 1.1.1a(3)

JOB OR TASK: Lubricate and Hand Operate Range Valves

REFERENCES & EQUIPMENT

1. References Stating When Job Performed	W 32-03(a)
2. References Stating How Job Performed	As above
3. Job Aids Required (Tools, Test Equipment)	Grease Gun Tool Hand Setting Assembly Spanner
4. Actual Equipment and Parts Required	Range Valves MK NC 1

(Tumble)

Fig. 63.--Task description sheet (1)

244A

WHAT TO DO	HOW TO DO IT	KEY POINTS
1. Lubricate Range Valve.	a. Insert grease gun fitting over grease nipple and pump two shots of 3-CP-601 to each nipple. (7 in number).	1a. Ensure that the grease gun has the proper grease.
2. Hand operate Range Valve.	a. Remove plug and insert tool hand setting assembly, and screw down into place.	2b. and 2c. This operation is to check for freedom of movement. If valve does not move freely, report it to your immediate supervisor.
	b. Wind tool handle clockwise until valve comes hard against its stop.*	
	c. Wind tool handle counter-clockwise until against other stop.*	*NOTE: Freedom of movement can be judged only if tradesmen has experienced the ease with which a properly working range valve can be hand operated.
	d. Wind tool handle clockwise to lining up mark. (640 yards).	
	e. Remove tool hand setting assembly and re-place plug.	

T. P. S. REFERENCE	1.1.1c(3)
JOB OR TASK:	CHECK REMOTE DEPTH SETTING CIRCUITS

REFERENCES & EQUIPMENT

1. References Stating When Job Performed	W 30(a)
2..References Stating How Job Performed	Not available.
3. Job Aids Required (Tools, Test Equipment)	Nil
4. Actual Equipment and Parts Required.	TASCO's Panel. Depth Setting Control Panel Weapon Control Panel Mounting Control Switch Captain's Switch.

(Tumble)

Fig. 64.--Task description sheet (2)

245.A

WHAT TO DO	HOW TO DO IT	KEY POINTS
1. Test depth setting from S.C.R.	a. Switch on all power.	
	b. Load mountings with MK 6 test bombs.	1b. Do not fit impulse cartridges.
	c. Make the following switches: (i) Action/Practice to ACTION. (ii) Normal/Emergency to NORMAL. (iii) M.C.S. to TRAIN. (iv) Safe/Test/Fire to FIRE. (v) Captains Safe/Ready switch to READY.	1c. Ensure mounting is in firing arc.
	d. All S.C.R. equipment in correct state to fire.	
	e. Have S.C.R. set depth on computer.	
	f. Have S.C.R. fire.	1f. Note depth set indicator corresponds with depth set on computor.
	g. Home fuses.	
2. Test depth setting from TASCO's Panel.	a. Set depth on TASCO's Panel by hand.	
	b. Fire from TASCO's Panel.	2b. Note depth set indicator corresponds with depth set on TASCO's Panel.
	c. Home fuses.	

T. P. S. REFERENCE 1.1.1(e)(2)

JOB OR TASK: CHECKS CORRECT OPERATION OF ROLL AND PITCH LIMIT SWITCHES

REFERENCES & EQUIPMENT

1. References Stating When Job Performed	Planned Maintenance Schedule W 32.03-01(a) Routine 0.1(b)(1)
2. References Stating How Job Performed	As above.
3. Job Aids Required (Tools, Test Equipment)	Nil
4. Actual Equipment and Parts Required	Mortar Mounting 12AA Amplifiers Plane Converter or Sonar Control Unit MK 48 Panel (Roll, Stow, Load Transmitters)

(Tumble)

Fig. 65.--Task description sheet (3)

246A.

WHAT TO DO	HOW TO DO IT	KEY POINTS
1. Check operation of Pitch Limit Switch.	a. Switch on all power and allow equipment to warm up for 20 minutes. b. Check and set up balance and sensitivity of 27M and 8D Pitch amplifiers. c. Set Trajectory Bearing to zero degrees. d. Put Mounting Control Switch (MCS) to TRAIN. e. Check that mounting slows down before hitting the stops.* f. Set Pitch stow angle to 50 degrees forward. g. Set Roll stow angle to 0 degrees. h. Put MCS to STOW position. i. Check that mounting slows down before hitting the stops.* j. Set Trajectory bearing to 180 degrees. k. Set Pitch stow angle to 50 degrees aft. l. Put MCS to STOW position. m. Check that the mounting slows down before hitting the stops.*	1.c. Trajectory bearing can be set by the Sonar Control Unit or applied manually at the Plane Converter. 1.e. Angle settings are carried out at the MK 48 Panel preset transmitters. *NOTE: In this operational check, correct operation is determined by visual check of manner in which mounting moves into the mechanical stops, after 1d, 1h, 1m, 2e and 2k. Mortar must have decelerated to zero velocity by the moment of contact with the stops.
2. Check operation of Roll Limit Switch	a. Set Trajectory to 90 degrees starboard. b. Put MCS to TRAIN. c. Set Roll Stow angle to 70 degrees starboard. d. Set Pitch Stow angle to zero degrees. e. Put MCS to STOW. f. Check that mounting slows down before hitting the stops.* g. Set Trajectory bearing to 90 degrees port. h. Put MCS to TRAIN. i. Set Roll Stow angle to 70 degrees port. j. Put MCS to STOW. k. Check that the mounting slows down before hitting the stops.*	
3. Bring equipment back to normal.	a. Put MCS to STANDBY. b. Set Roll Stow angle to 50 degrees on the loading side and lock both the Pitch and Roll transmitters. c. Switch off all power.	
4. If above operational checks are incorrect proceed with adjustment according to 1.2.1c.(5) paras. 5-8.		

develop, and in devising 'progress' objectives as sub-goals in achieving these behaviours.

In further consideration of (2) and (3) above it has been realized that the "How to do it" steps often have to be studied further to identify the nature of the learning activity involved in each step. The kinds of activities being identified have been defined by Gagné and Mager as cited in Chapter III. This has been a recent addition to the procedure and has been introduced as the standards have been produced. While the types of learning have not been included in the present documents, it is expected that they would be inserted in the Task/Job description sheets in future.

With the information on the trade tasks now recorded, it has been possible to allocate tasks by pay level, using the judgement of the experienced tradesmen on the team and bearing in mind the manpower provided for each ship. The allocations made have been recorded beside each task in figures 61 and 62. All the tasks for a particular pay level form the critical reference base for the development of the training standards for that level.

The <u>Training Standards</u> are prepared for each pay level to specify the learning goals which a trainee must achieve under training to be qualified as trained for the particular Pay Level. These learning goals are expressed in the form of behavioural objectives, each of which is referenced to a job or task, or the group of jobs or tasks for which it provides a training standard. As training may be provided by formal course and/or on-the-job instruction and practice, training standards must be developed to provide for both kinds of training environment.

In consideration of the various kinds of skills to be acquired by the tradesman and the requirement to establish the link between training and operational requirements, it has been found necessary to develop several types of objectives. To-date three types have been generated and are defined as follows:

Class I Objective: - This objective expresses the behaviour which the trainee must exhibit following actual training on the performance of an operational job or task as proof that he is indeed able to do the operational job or task. In some instances, a job or task may have more than one Class I Objective. (See Figure 66).

Class II Objective: - This objective expresses the optimum level of job mastery that can be achieved within the limitations of the training environment. It may consist of performance of a job or task in its entirety but under simulated operational or highly artificial conditions. It may consist of performance of an operational job or task, including some of the operational skills involved. Alternatively, because of lack of operational facilities, it may consist merely of stating the procedures to be followed in doing the job or task. In any case, it must contain mental and/or physical skills involved in the step-by-step procedure

TRAINING STANDARDS (1)

TRADE: WPMN U **PAY LEVEL:** 3

TR. PER. STD. JOB REF. 1

TOPIC 3.02 A/S Mortar MK NC 10 - Mounting and Handling Room

COURSE TRAINING STANDARD				SEA TRAINING STANDARD		
OBJ. TYPE AND NO.	PERFORMANCE OBJECTIVES	S/M REFERENCE	CLASS TIME	OBJ. TYPE AND NO.	PERFORMANCE OBJECTIVES	S/M REF.
	LUBRICATE AND HAND OPERATE THE RANGE VALVES 1.1.1a(3) and 1.2.1a(3)					
CLASS II 8.	At the mounting the trainee will locate the seven range valve lubrication points.	BRCN 2906(1) Figure 97		CLASS I	Using grease gun with 3-GP-691 the trainee will pump 2 shots to each of the 7 nipples of the range valve.	
CLASS I 9.	The trainee will check the range valve for freedom of movement by fitting the hand setting tool and manually operating the range valve.	Task Description				
CLASS I 10.	The trainee will manually line up the range valve to the 640 yard calibration mark.	BRCN 2906(1) p. 2-6 para 26-32 Figure 8	1			

Commentary: Note Class I objective in Sea Training Standard. This is a task. Training beyond achievement of objective 8 on Course side required because each student cannot lubricate valves on training mounting. Objective 8 is designated as Class II as location of lubrication points is part of task which can be carried out on training mounting.

Note objectives 9 and 10 are designated as Class I. Students actually perform tasks on training mounting as required on mounting at sea. No Sea Training required in these items, hence no objectives on Sea Training side.

Figure 66.

of doing the job or tasks, and it must be the best performance-learning goal feasible.

Where Class II Objectives appear in the Course Training Standard they will be complemented usually by one or more Class I Objectives in the Sea Training Standard to ensure that the operational skills or knowledge are achieved in an operational situation. (See Figures 66 and 68).

Class III Objectives: - These objectives state activities which the trainee must perform as goals for the acquisition of knowledge or mental skills required in relation to the jobs or including the making of judgements, and decisions, and the development of proper attitudes. These objectives are often referred to as "enabling objectives". (See Figures 66 and 67).

Classification of objectives in this way is considered necessary in developing training standards and controls for the following reasons.

1) Because of the need to keep training requirements at sea at a minimum consistent with proper trade training, each job or task is considered from the aspect: "In recognition of the capabilities and necessary limitations of training ashore, what is the optimum learning behaviour in respect to the job or task that can be achieved on course?" When the objective for this behaviour is established, a decision is made as to whether, after accomplishing this objective, a trainee can perform the

TRAINING STANDARDS (2)

TRADE: WPMN U **PAY LEVEL:** 3

TR. PER. STD. JOB REF. 1

TOPIC 3.02 A/S Mortar MK NC 10 - Mounting and Handling Room

COURSE TRAINING STANDARD				SEA TRAINING STANDARD		
OBJ. TYPE AND NO.	PERFORMANCE OBJECTIVES	S/M REFERENCE	CLASS TIME Periods	OBJ. TYPE AND NO.	PERFORMANCE OBJECTIVES	S/M REF.
	PERFORMS DRILL PROCEDURES 1.1.1L(1) and (2), 1.1.1m(1-6)					
CLASS I 14.	The trainee will perform the duties of No.2 and No. 3 of the Mortar Crew during the following: (a) Loading drill. (b) Drill to exercise crew. (c) Single barrel firing. (d) Misfire Drill (Peacetime). (e) Misfire drill (Wartime). (f) Drill for changing from remote to local. (g) Drill for mounting untrainable due to power failure. (h) Drill for complete system failure.	Drill Book August 1967 Page 16 Page 10-11 Page 17-18 Page 18-20 Page 20-22 Page 23 & 25 Page 25-26 Page 28-29			Commentary: Note the absence of objectives on Sea Training Standard - all drill can be developed and practiced to desired level on Training mounting. Dummy bombs and cartridges are used and firing is simulated. All activities at high degree of fidelity. Therefore objective 14 is designated level I and no further instruction considered necessary. Practice at sea will develop individual and team skills. Note that objectives 15 and 16 are designated Class III. Development of an attitude toward safe practice is critical to the drill.	
CLASS III 15.	The trainee will state: (a) The purpose of the order "STILL" (b) Who may give the order. (c) The action taken by the crew when the "STILL" is given.	Drill Book August 1967				
CLASS III 16.	The trainee will state the importance of keeping the Safety Interlock Handle in his possession at all times while the mounting is in the manual mode of operation.	Drill Book August 1967				
			9			

Figure 67.

TRAINING STANDARDS (3)

TRADE: WPMN U **PAY LEVEL:** 3

TR. PER. STD. JOB REF. 1-5

TOPIC 3.01 General Trade Knowledge, Skills and Attitudes

COURSE TRAINING STANDARD				SEA TRAINING STANDARD		
OBJ. TYPE AND NO.	PERFORMANCE OBJECTIVES	S/M REFERENCE	CLASS TIME Periods	OBJ. TYPE AND NO.	PERFORMANCE OBJECTIVES	S/M REF.
	E. COMMON MAINTENANCE PROCEDURES					
Class III. 6.	The trainee will state the fundamental objective of the Planned Maintenance System.	BRCN 6429 Part 1 1-3(1)	.25		Commentary: Objective 6 is attitudinal and is at the memory level of learning.	
CLASS III. 7.	The trainee will select the advantages of the Planned Maintenance System from a listing of several plausible statements.	BRCN 6429 Part 1 1-3(2)	.25		Objective 7 is attitudinal and is at the recognition level of learning.	
					Objective 8 is a skill and forms part of every Planned Maintenance Schedule assigned to this Pay Level. It is simulated in the classroom with a high degree of fidelity.	
CLASS II 8.	Given a Routine Detail Card with selected routine completion times, the trainee will complete the following required entries on the Maintenance Control Card: a. Routine Periodicity. b. Time in decimals. c. Completion date. d. Signature.	BRCN 6429 Part 7 7-2(5 & 6)	.5		No objectives on Sea Training side as task of completing Routine Detail Card represents a common requirement for many tasks.	

Figure 68.

the job or task. If he can, it is termed a Class I Objective. If not, it is termed a Class II Objective and suitable Class I Objectives must be written for the Sea Training Standard. Next, an analysis is carried out in respect to the job or task to determine, for reasons of attitude, judgement, etc., what additional objectives are required. These are Class III Objectives.

2) With each objective designated as Class I, II or III students, trainers, and examiners are shown which of the objectives are critical to the actual performance of the job, and which are concerned with quality of performance, ability to make judgements, etc. Thus, emphasis in teaching, in learning and in weighting of examinations can be arranged accordingly.

3) Adherence to the classes of objectives defined herein ensures that a mass of detailed step-by-step objectives do not appear in the Training Standard. While step-by-step objectives may be needed by the trainer in the development of his lesson plans to achieve the standard, they are not a legitimate part of the final Standard as such. These sub-goals, or progress objectives as they may be called, are formulated as a matter of training strategy, and their development and method of use are properly the responsibility

and prerogative of the trainer. Figures 69 and 70 illustrate examples of trainer documents derived from training standards.

The decisions concerning the form of objectives to be included in the Training Standards have been the most difficult to make. There are two extremes, neither of which seem to provide the complete answer. At one extreme the standard could contain only a listing of all the tasks of a particular pay level expressed in objective form, and nothing more. Since the tradesman's proven ability to do the tasks assigned to him on the job is the ultimate criterion for the validation of the training program, this is a very tempting approach. At the other end of the scale, one is equally tempted to develop objectives which are highly fact-and-theory oriented with the dangerous assumption that the tradesman will be capable of transferring his ability in learning complex practical job situation.[3] There is no doubt that the approach being reported here is highly task-oriented and all decisions on the nature of objectives to be included in the Training Standards are biased in favour of the task.

In figures 66 and 68 the objectives are related to particular tasks which have been underlined and referenced to the Trade Performance Standards. However, no particular

[3]There is an interesting parallel here to the arguments about the difference between training and education - specifics vs generalities.

UNIT COVER SHEET

School: Fleet School, Halifax	**Date:** May, 1968
Section: Weapons (Underwater)	**Revised Date:** Original

Course: Weapons Underwater PL3

Topic: General Trade Knowledge, Skills and Attitudes

Unit: I. B. Planned Maintenance System.

Duration in Periods: 2 (100 min.)

T.P.S. Task Reference (s): (a) 5.2.3a(3)

(b) 5.2.3a(4)

Instructional Aids:
(a) Vu-graphs
(b) Chalkboard
(c) Routine Detail Card
(d) Maintenance Control Card

Reference (s): (a) BRCN 6429

P.T.O.

Figure 69.

255A

UNIT OBJECTIVES

Lesson: I. The trainee will state the fundamental objectives of the Planned Maintenance System.

II. The trainee will select the advantages of the Planned Maintenance System from a listing of several plausible statements.

III. Given a Routine Detail Card with selected routines and routine completion times the trainee will complete the following required entries on the Maintenance Control Card:

(a) Routine periodicity.

(b) Time in decimals.

(c) Completion date.

(d) Signature.

LESSON SPECIFICATION

Title:

SOLO(s)	INSTRUCTOR ACTIVITY
The trainee will: 1. Explain the need for Preventive Maintenance. 2. State the fundamental objectives of the Planned Maintenance System	Ref. BRCN 6429 1.1-2 & 1-3.(1) 1.01 - using the BRCN 6429 inform the trainee on maintenance that was carried out in the past example - mainly directed to repair of defects, and the need for preventative maintenance today in the R.C.N. .02 - Film - 2.01 - the fundamental objective is the elimination of equipment breakdowns and malfunctions.
1. Using the BRCN 6429 Part 1.1-3(2) the trainee will define the advantages of the Planned Maintenance System. 2. Select the advantage of the Planned Maintenance System from a listing of several plausible statements.	Ref. BRCN 6429 Part 1.1-3(2) 1.01 - have each trainee draw a BRCN 6429. .02 - cover each advantage and explain each paragraph in detail. 2.01 - give the trainee a listing of several of the statements and test him on his ability to select the advantages. example - elimination of non-standard maintenance practices can be achieved by a system of organized maintenance - Standardization. P.T.O.

Figure 70.

256A

LESSON SPECIFICATION

Title:

SOLO(s)	INSTRUCTOR ACTIVITY
	Ref. BRCN 6429 Chap. 6-4 BRCN 6429 Part 7.7-2(5&6)
1. Describe a Routine Detail Card and Control Card.	1.01 - give each trainee a Routine Detail Card and Control Card and with the trainee describe each allocation on the Cards.
2. Given a Routine Detail Card with selected routines and routine completion times. The trainee will complete the following required entries on the Maintenance Control Card.	2.01 - visually present a completed Maintenance Control Card and go over it with the trainee. Suggestion to Instructor: Ensure the trainee realizes the importance of his signature on completion of entry. .02 - provide each trainee with a Maintenance Control Card and have him fill in the appropriate entries.

tasks or tasks are referenced for the objectives in figure 67 as these task-oriented objectives are related to maintenance practices common to a large group of Pay Level 3 tasks.

However, each decision is made on the basis of careful consideration of the nature of the relevant tasks, the nature of the theory back-up required,how critical the task is to the job, the periodicity of task performance, the nature of the training environment and the problems of transfer from the training environment to the operational environment.

The side-by-side format for Course and On-the-Job (Sea) Training Standards was adopted for the following reasons:

1) In preparing their training strategies, training personnel of each training environment can easily ascertain what training has gone before, or will follow. Thus, they can plan, revise, and relate instruction as advisable.
2) In cases where it transpires that objectives of the Training Standard are invalid, or cause inefficiencies in terms of training effort, an analysis of the objectives applying to the particular job or skill can be made more readily.

Other Work Under Consideration

Two areas of study which have not been considered in this project to date are methods of assessment of objective achievement and feedback. With regard to assessment, there seems to be little doubt that present examinations are going to have to be looked at very carefully; consideration will have to be given to performance-oriented testing. With regard to feedback, consideration must be given to internal and external communication for rapid assessment and reporting of results. This will be essential for the training system to be self-correcting and dynamic without the disruptive oscillation which can occur when feedback is delayed, erroneous, or missing completely.

Conclusion

The following observations can be made based on the project results to date:

1) The challenge of the Pilot Project on the analysis and synthesis of trade training requirements is essentially that of whether or not Service training can successfully adopt the System Concept of Training and the principles of Programmed Learning. With trade requirements precisely specified and valid standards of training established, the foundation will have been established, and upon this foundation effective and efficient training systems can be constructed. Without it, training will be subject to uncertainities, inaccuracies, and opinion not based on fact, and must thus be inefficient.

2) It is considered that the Pilot Project has already

shown the feasibility of establishing the fundamental documents of training and has, in the main, devised procedures and documentation for carrying out the process. Undoubtedly, the Pilot Project, and any subsequent analysis and writing of standards, will contain errors caused by oversight, lack of understanding, and mistakes in judgement. However, because of the form of the documents, such errors can be corrected as experience dictates.

3) The Pilot Project is achieving a further benefit to training in the form of developing within team members, the skills, insights, and identification with the System Concept of Training that prepare them to assist and guide training development and implementation. Observation indicates that members of the present team feel personally committed to the success of the project, and are anxious to see it carried to fruition in the form of improved training procedures and controls.

4) In considering the ultimate benefits to be achieved from developing these procedures for training analysis and documentation, it is expected that the very large initial effort required by this project will be repaid many times over by increased efficiency of training programmes,

and the increased productivity of their graduates.

When the validated Training Standards are met by the graduate tradesmen, he will:

1) Be able to do all the jobs of the Pay Level for which he has been trained;
2) Possess the knowledge and mental skills necessary to perform calculations, organize work, assess quality of workmanship, make decisions, etc. as may be required in performing the jobs and tasks of his particular Pay Level, and
3) Possess knowledge considered effective in inducing attitudes within himself, including pride in workmanship, and observation of safety precautions.

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