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ABSTRACT

The five papers which comprise this volume share a common interest in the relationship of the problems of instructional technology to the insights of the behavioral sciences. The first chapter is concerned with the applications of present knowledge and empirical methodology to the solution of particular behavioral problems, an activity that presently consumes much of the time of the instructional technologist. The second paper focuses upon the characteristics of human learning which typify man, while following this is an analysis of the manner in which humans differ with respect to learning, [illegible]nismically and situationally. The fourth chapter summarizes recent m[illegible]a research and considers the scientific and instructional uses of various technologies. The volume concludes with an examination of the other side of the interface--the behavioral sciences. This last chapter addresses the questions of what is the essential structure of the behavioral sciences and of how this structure lends itself to the task of the instructional technologist, which is to identify the optimal means of forming behavior in socially acceptable wavs. (Author/LB)

CONTRIBUTIONS OF BEHAVIORAL SCIENCE TO INSTRUCTIONAL TECHNOLOGY 2

A RESOURCE BOOK FOR MEDIA SPECIALISTS

THE COGNITIVE DOMAIN

A CSC Mediabook

The National Special Media Institutes is a consortium of Michigan State University, University of Southern California, United States International University and Syracuse University.

Contributions of Behavioral Science to Instructional Technology

As a consortium of higher education institutions the National Special Media Institutes (NSMI) represents a joint effort to work on projects of national interest which are significant to the development of the field of instructional technology. A series of seminars sponsored by the U.S. Office of Education and coordinated by the Teaching Research Division of the Oregon State System of Higher Education probed the relationship between the behavioral sciences and the field of instructional technology.

The first seminar was devoted to the cognitive area, the second to the affective area and the third to the psychomotor area. Because of keen interest in the affective area the results of that seminar were published first. The third volume in this series on the psychomotor area will appear shortly after this volume. These three volumes represent new substantive inputs to the field of instructional technology. As the field grew out of its traditional audiovisual product orientation, new insights were required to emphasize the process approach. The behavioral sciences seemed to have more to contribute in this vein than any other substantive field.

The credit for these volumes and the work of the National Special Media Institutes should be given to the late Dr. James D. Finn of the University of Southern California who originally conceived the consortium and stressed the need for new inputs to the growing field of instructional technology.

The papers included in this publication were written pursuant to a grant from the Bureau of Educational Personnel Development, Office of Education, U.S. Department of Health, Education and Welfare.

CONTRIBUTIONS OF BEHAVIORAL SCIENCE TO INSTRUCTIONAL TECHNOLOGY **2**

The Cognitive Domain

—A Resource Book for Media Specialists
Published for the National Special Media Institutes

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Introduction

Jack V. Edling

That inventions result in new occupations is a fact easily demonstrated: the airplane needed a pilot; television brought the repairman; and the motion picture contributed the censor. But inventions also create new, sometimes complex, enterprises. And as these enterprises develop, new specialists emerge as designers, builders, buyers, operators, trainers, maintainers, and sellers. However, complexity also develops generalists. The manager, administrator, and executive emerge first from the ranks of the specialist and later through formal training. Then the manager analyzes, organizes, and coordinates specialists into ever larger, more complex enterprises. At some point, first from among the generalists and later by formal training, a new breed of specialist appears, one who is knowledgeable not only in a specific enterprise but one who sees relationships among services performed by others. And when enterprises perform related social services (whether in transportation, communication, entertainment or any other area) a new, higher-order specialist inevitably evolves. But instead of supplanting the giant of industry or labor or government, he advises and guides him, eventually influencing the very nature of the activity. This "new breed" we name "technologists," to differentiate them from "specialists" and "generalists," and to indicate they "study" the "applied sciences." A specialist with a high degree of skill is often called a "technician," but this term should not be confused with "technologist"—the term we use for the person who studies at a high level the application of inventions to social purposes.

The Education Industry

Conceived of as inventions, schools needed teachers. And schools have spawned large, complex enterprises, including many types of youth and adult educational agencies, publishers, equipment manufacturers, radio and TV stations, government, labor and other organizations. Multitudes of specialists have emerged. In addition to teachers are supervisors, principals, librarians, audiovisualists, counselors, architects, and others. The educational generalist has also developed. Highly skilled executives and leaders direct the many interdependent educational enterprises. The "new breed"—the technologists—now perceive that all educational enterprises contribute to the general activity of developing or forming behavior Consequently, a "behavior industry" is now identifiable, paralleling the transportation, communication, entertainment and other industries and having an extensive technological base. Unfortunately, the term "behavior" has become associated with a kind of mechanistic animal conditioning. Therefore, to avoid the negative connotation, the term "education industry" is employed to encompass those contributing to the modification of behavior in socially approved ways. It is a giant industry directly involving more than 55 million people in the United States, and second only to defense in public expenditures.

The Instructional Technologist

In the transportation industry, the technologist wants to move people and products. In communication, he is involved with the transmission of information. In entertainment, he is concerned with the pleasures of people. And his concern in the education industry is modifying or forming the behavior of individuals. Since instruction is the means employed to reach his goals we shall name him an "instructional" technologist.

Of course, the educational specialist and generalist are also concerned with forming behavior, as the pilot and airline executive are concerned with moving people and products. But the relation of the pilot and executive to the airplane and its movement of products is significantly different from that of the transportation technologist's. For example, the pilot (a specialist and technician) interacts directly with the inventions to perform a service. And the executive (a generalist) interacts with the specialist to enhance the service. The transportation technologist, on the other hand, is concerned neither with the invention nor the specialist, but, instead, with the movement of people and products. If he can conceive of other inventions to better achieve desired ends and can provide the decison makers in his society with whatever they require to cause them to adopt a newer technology, then the airplane, pilot, and executive will all be reassigned in accordance with requirements of the newer technology. Neither the pilot nor the executive would likely undertake the reassignment without the activities of the technologist, whether he is called an operations analyst, a systems engineer, or Secretary of Defense.

The goal of the instructional technologist is to identify the optimal means for forming behavior; thus he is concerned with ascertaining behaviors his society needs and wants developed, and the means to develop them. Also, he must provide decision makers with whatever new knowledge they need to adopt appropriate technology. He could be thought of as a new kind of applied behavioral scientist. However, many behavioral scientists consider their work to be of an "applied" (rather than "basic") nature and this term might only cause confusion and resentment. Yet, almost all behavioral scientists (basic and applied) would welcome cooperation in *collating, interpreting*, and *translating* general knowledge to make it more useful. And surely, the educator, both generalist and specialist, would welcome cooperation in *developing* the tools and techniques needed in his everyday work.

The Behavioral Sciences--An Introduction

In the following chapters frequent references to the behavioral sciences punctuate descriptions of technology which emanated from behavioral scientists' attempts to solve problems. Placing the "behavioral sciences" in such a cardinal position suggests that a brief introductory description may be useful. Two kinds of short descriptions will be given: A general definition of the term and a set of representative examples. However, the reader should recall that terms signifying complex processes and areas do not lend themselves to terse definitions. Much in the order of "love" the "behavioral sciences" refer to an open-ended set of activities not clearly branded to distinguish them from others.

The Term

The emphasis upon behavior in the term stems in part from the positivist influence of the early behaviorists in psychology. Hull, in fact, used "behavioral science" throughout his 1943 *Principles of Behavior*. However, usage of the term languished, as evidenced by the absence in publications, until the end of World War II. At that time several factors converged to stimulate widespread r[illegible] One of these was merely the removal of some unfortunate co[illegible]tion of the older term "Social Science." "Another reason for se[illegible] a substitute for the older terminology is the identification on the part of some laymen of the social sciences with social work and with socialism. In several situations, this confusion has had irritating consequences. One way of avoiding this misunderstanding is to rename this group of academic disciplines" (Tyler, 1964).

An interesting account of a possible financial godfather of the term is given by Berelson.

> The interest in clarifying the term I might add, has not been altogether intellectual in character. Although the phrase "behavioral science" was used from time to time over a period of years, it never caught on until about twelve years ago when the Ford Foundation used the term as a shorthand description of its program on Individual Behavior in Human Relations. For about six years in the 1950's, the Foundation operated a Behavioral Sciences Program and supported this field with several millions of dollars. It was then that some people began to wonder if they too were not behavioral scientists after all! (Berelson, 1964).

Other influences, more laudatory by academic standards, also contributed. Advances in several fields were coupled with interdisciplinary contacts. New methods and ideas for scientific investigation placed some former areas in a scholarly rather than a scientific frame of emphasis. Attention to original data, usually behavioral indices rather than the documentary practices associated with history tended to mark these areas.

The lines of demarcation are quite loose, but in general the behavioral sciences tend to be a substantial portion of psychology, anthropology, and sociology.

> But the concept includes both more and less than that. It includes less in the sense that some aspects of anthropology and psychology are not typically considered part of the behavioral sciences, *e. g.*, certain archeological and physical interests in the former and certain technical interests like vision and hearing in the latter. And it includes more in the sense that a number of behavioral interests in other disciplines have an equal claim to inclusion: *e.g.*, from political science and law, concern with actual political and legal behavior as distinct from the traditional formal concern with constitutions, governments, laws, and ideologies; from psychiatry, interest in deviant behavior, the motivational and emotional life, and the behavioral consequences of physiological change or chemical intervention; from geography, the behavioral implications of man's physical environment; from biology, the physiological and evolutionary bases of human behavior; from economics and business, such topics as consumer behavior, industrial morale, and the empirical analysis of businessmen's decisions; from history, broad generalizations about man's behavior under historical conditions. (Berelson, 1964)

The term began to proliferate. Textbooks, journals, and centers for advanced study incorporated it in their titles. By 1962 a President's Science Advisory Committee issued a report which presents an accepted definition of the term!

> The behavioral sciences have both a fundamental and an applied aspect. As fundamental sciences they are concerned with the careful, dispassionate discovery and analysis of the basic facts of human behavior, individual and social, and with the construction, testing and revision of theories to explain observed regularities. As applied science, they are concerned with the application of facts, tested theories, and developed insight to questions of practice in such areas as education, mental health, personnel utilization, city planning, communications and the problems of emerging countries. Behavioral scientists use methods common to all sciences: observation, instrumentation, field and laboratory experiments, statistical analysis of data, construction of models and theories, and good hard thinking.
>
> Perhaps the first impression one has of behavioral science is the enormous scope and variety of its problems and its methods.

A Resource Book for the Instructional Technologist

The following chapters hopefully will begin to relate problems of the instructional technologist to insights and evidence from the behavioral sciences. The numerous fields of inquiry in the behavioral sciences, employing diverse methodologies, may contribute to the solution of problems confronting the education industry. In some cases, the relationship between problem and available knowledge may appear to be remote and tenuous; in others the focus on a particular problem may be so sharp as to make the problem appear not generally significant.

The first chapter is concerned with the application of present knowledge, and empirical methodology, to the solution of particular behavioral problems, an activity that presently consumes much of the time of the instructional technologist. It will be seen, however, that this does not involve merely or even primarily the application of principles derived from the behavioral sciences. Such principles are both insufficient in number and uncertain in applicability to be applied prescriptively.

In two respects present activity of the instructional technologist is more appropriately described as "backward science" than as technology. First, an attempt is made to *particularize* rather than *generalize*. The possibility of error in presuming that what is generally true is true in a specific case is the same as presuming that what is true in a specific case is generally true. Thus the solution of a specific instructional problem requires that even generally accepted principles of the behavioral sciences be tested anew.

Second, while most typically scientific inquiry involves the search for explanations of cause-effect relationships, with the hope that such explanations will ultimately have utility, the behavioral technologist looks systematically for causal factors that will produce a given utilitarian effect, with the hope that their relationsip may ultimately be explained.

The second chapter is focused on characteristics of human learnnng that typify man. Following this is a chapter on the manner in which humans differ with respect to learning, organismically and situationally.

The fourth chapter summarizes recent "media research," and considers the scientific and instructional uses of various technologies. It should become apparent that the term "media research" is deceptive—no more appropriate than "microscope research" to the work of a bacteriologist. Media not only have properties that make them useful in research but in developing behavior as well. Combined, these facts offer an effective interface between the behavioral sciences and developing behavior.

The last chapter is concerned with the other side of the interface—the behavioral sciences. The chapter addresses the question of what is the essential structure of the behavioral sciences and how does this structure lend itself to the task of the instructional technologist? However, the behavioral sciences are not products only. They are processes. The final chapter delineates this process-product relationship and emphasizes some of the internal diversities that mark approaches in the behavioral sciences.

The Attempted Consensus

The method employed in the development of these chapters could be described as a kind of *attempted consensus*. Each chapter was developed initially by the person named on the title page. A symposium was then organized with people from the behavioral sciences and instructional technology. After the technologists had verified issues, the scientists and philosophers were asked to review and critique the papers with a view to being extensive rather than intensive, *i.e.*, attempting in a relatively short paper to identify as many ideas, concepts, or principles as seemed relevant to developing behavior without exploring the topic in depth. Extensive bibliographies are provided for those who desire to pursue a lead more extensively.

When the scientists and technologists had read and prepared a critique with suggested additions, deletions and modifications, the symposium was convened to determine the degree of consensus that existed. The writers of the chapters then attempted to incorporate the recommended changes into present versions. The symposium members, however, have not reviewed the second version and cannot, therefore, assume responsibility for content. The members of the symposium were the following:

John Barson (Instructional Technology–Systems Development) Michigan State University

Eli M. Bower (Psychology–Developmental) National Institutes of Health

Allen Brownsword (History) U.S. Office of Education

Paul R. Christensen (Psychology–Human Abilities) University of California at Santa Barbara

Donald P. Ely (Instructional Technology–Instructional Development) Syracuse University

James A. Finn (Instructional Technology–Theory) University of Southern California

Arthur A. Lumsdaine (Psychology–Learning and Human Performance) University of Washington

Melvin H. Marx (Psychology–Learning and Motivation Theory) University of Missouri

Charles F. Schuller (Instructional Technology–National Policies) Michigan State University

Fred L. Strodtbeck (Social Psychology) University of Chicago

James B. Watson (Social Anthropology) University of Washington

The Systems Approach to Instructional Development

Dale G. Hamreus

Focus

The primary purpose of this paper is to identify for the reader what is meant by the systems approach to instructional development. If the instructional technologist is to get maximum use from media in improving learning outcomes he must be able to answer how, what, and when media can mosteffectively be employed. To answer these questions he must know what specific learning outcomes are expected of students. Also, the questions must all be considered within the constraints of the educational industry: learner differences, learner outcomes, learning processes, and the conditions for learning. What this all leads to is the need to manage and operate a set of complex elements that make up the particular sub-system in the educational industry within which the instructional technologist happens to confront an instructional problem.

A twenty-two step maxi- and a six-step mini-systems approach model are presented. The maxi-model is for the educational technologist who has "everything" (support personnel and facilities, time, money), and the mini-model is for the individual technologist who has limited assistance and support yet is enthusiastic about improving instruction. The dehumanizing issue in the systems approach is discussed. Finally, examples of systems development models are presented, gaps in our present systems approach are identified, and methods for bridging gap explored. A list of references is provided for the reader who wishes to extend his study.

We in education have come to accept the fact that schools, beside being places where learning occurs, are, in the words of U. S. Commissioner of Education Harold Howe, "economic enterprises" (1967, p. 40). In other words, a school just doesn't happen, it represents public funds being intelligently expended in the management of physical and human resources for the purpose of producing certain desired changes in pupils' behavior.

This is not to say that the strategy and technology for achieving what the educational program in any particular school district needs to become has arrived. On the contrary, what we are now accomplishing is probably just scratching the surface of man's ability to learn. Educators have long felt themselves qualified to specify the broad objectives of an instructional program, but the means of achieving these objectives have often proven to be extremely elusive. What we face is how to get the most out of our educational plans.

In striving to tighten up this means-ends incongruity, behavioral technologists are becoming more and more aware of the vast amounts of information and technical know-how required to bridge this gap. What all this speaks for is the need for a better science and technology of instruction.

The chapters that follow will give attention to some aspects of the philosophy of science, human learning characteristics and how learners differ which contribute to the information bridge. This chapter will give attention to the methodology of the systems approach to instructional development as a technological means for helping bridge this means-end gap.

The systems approach can literally be said to have had its origins in the beginning of man in man's relations with his environment. The notion is inherent in what has been called the ecological model--that things are related to each other in such a way that by affecting one part of the environment, if the environment is tight enough, it will affect other parts of the environment.

In terms of the more modern concept of systems approach, its antecedents are attributed to military applications developed during World War II. From these war experiences have emerged complex weapons systems, such as the NIKE air-defense missile system; production functions in industry, such as the Boeing 727 airliner; and information processing in business, such as the IBM data reduction system. Because the educational system involves the interaction of many complex sub-systems--e.g., instructional lessons, classroom schedules, audio-visual support, personnel--some behavioral technologists are attempting to modify and apply the principles and techniques used in weaponry development and production activity to the educational industry.

General Meaning of the Systems Approach

Broadly speaking the systems approach can be regarded as an empirically derived framework which serves as a guide for systematically proceeding toward the solution of some defined problem in the educational industry.

Five things in the above statement should be amplified. First, although the use of the definite article --*the*-- in the term "the systems approach" implies a fixed set of operations which consists of a specific content, such an interpretation is false. The actions employed in using the systems approach to attack a defined instructional problem, follow a general strategy but are not fixed; rather, they change according to the nature of the problem and its context.

Second, the approach has been *empirically* derived. It is not a mathematically derived model which has emerged in the sterile environs of the laboratory; but, rather, has evolved, and continues to do so from real life experiences.

Third, the approach serves as a *guide* in attacking a problem solution: it provides an order whereby decision points critical in the problem solution can be systematically faced and necessary actions decided upon.

Fourth, the approach provides for a *systematic* attack on the problem. The problem and all of its elements are thoroughly considered (within the means available) and progress toward a solution regulated.

Fifth, a problem in the educational industry has been *defined*. Obviously, before any efforts toward solution can be initiated, the problem must be clearly distinguished. Often, a problem is "felt" before it is actually outlined or characterized. The systems approach can be generalized to attack such a felt need to determine its real nature; however, in the context of this chapter there isn't place to enter into such a discussion. The emphasis instead will be upon problems that have already been defined.

More specifically, what the systems approach offers in progressing toward a problem solution is an analytical planning and control method for designing and developing the various instructional parts and their interrelationships needed to accomplish the specified outcomes. A more formal definition prepared by Corrigan and Kaufman is as follows:

> *System approach*. Formal analytical planning methods for progressing from the specification of system mission objectives to the achievement of those objectives through the controlled and orderly specification of parts making up the total system and the integration of parts according to functions to be performed into a total system that achieves stated mission objectives (Corrigan and Kaufman, 1965, p. 71).

The concise statements just presented involve a combination of meanings that require considerable separation and definition before the concept of the systems approach can become unlocked. However, before beginning a refined step by step definition of the systems approach, and since the term system is so central, some clarification should be made regarding the use of the term.

The term system is defined as the assemblage of elements or entities united by some form of regular interaction or interdependence. General interpretation tends to relate the concept system to order, interdependence, or relatedness.[1] However, the term is frequently used both as a proper name referring to an order (collection) of entities–e.g., "The instructional system (order) includes the learner, teacher, message elements, interactions, etc."-e.g., "There needs to be system (order) in the lesson giving."

The importance of this distinction when considering the systems approach to instruction becomes immediately clear. The phrase, "systems approach to instructional development," when more completely stated, becomes systems approach to instructional *system* development. What obviously emerges when considering the distinction of the concept system is the need both to identify the entities that are to make up the instructional system to be developed and to define the order within and among these entities.

Thus, if we are to employ the systems approach in the development of an instructional system, whether we're concerned at the lesson level, the course level or the institutional level, one of the vital steps to be undertaken is to determine all the parts or elements in the instructional situation that go to make up the system and then determine the relationships of each part to each other and to the whole. The determination of these parts and their interrelationships is the very heart of the systems approach.

One additional and perhaps least understood distinction of a system should be briefly discussed. The elements of a system are not the real entities with which to be concerned in a systems approach to instructional development; rather it is with the *order among the properties* (qualities or states) of those entities. In other words, it is not the learner in instruction but the current characteristic or condition of the learner which is the entity in the system. It is not the conditions of learning but the quality or state of those conditions. Similarly, the learning process is not the conditions and the learner in the system, but the quality of those conditions and the state of the learner. This distinction between entities and properties of the entities in a system seems to be a difficult one to maintain but is a very important one.

Why Systems Approach?

The traditional instructional situation of today has been described by John Loughary as a "machine-independent" system (1966, p. 4). It is

[1] Reference is made to the publication by R. Jean Hills, *The Concept of System*. Eugene, Oregon, University of Oregon, CASEA, 1967, from which extensions were made in this chapter to the systems approach.

one where virtually all machines could be removed from the classroom without altering, in any substantial degree, the teacher's level of instructional operation. This is because "educators have *used* machines to assist them to achieve results which were *planned* independent of machines" (Loughary, 1966, p. 4).

Robert Heinich concludes that most audiovisual equipment in instruction today is brought into the instructional process at the classroom level to operate in a machine-independent system (Cochran, 1967). If this is true, then it must be similarly concluded that the role of the present media specialist in the instructional process is of little real contribution to the desired learning objectives. Such a conclusion is a harsh statement to make but is, unfortunately, more true than not. I should add that this is not because media specialists hold any less worthy professional intentions or desires, but rather because concerns for employing media resources in the instructional situation usually emerge after plans for learning outcomes have been completed rather than as an integral part of them.

What must occur is to bring the media specialist into a dependent relationship with the instructional process. One in which he is integrally involved in the instructional planning and development of instructional systems. The only way for media specialists to become a viable element in such a complex system as the educational one is through the systems approach. An excellent discussion of the emerging role of the media professional is to be found in the recent DAVI declarative statement (Norberg, 1967). The authors of this article contend that the role of the media specialist is changing from that of a maintainer and distributor of AV equipment to that of a systems designer who is significantly involved in the development of instructional systems.

Today's behavioral technologists who know what the systems approach is in developing instructional systems, might find the question "why" systems approach rather academic. They know that an organized, systematic approach to instructional development is essential to the production of an instructional system that works; i. e., one that achieves its objectives. To a novice, however, neither the "what" nor the "why" of systems approach are of general knowledge.

The concern is often expressed that to employ the systems approach in instructional development is to dehumanize education; i.e., to relegate man to a limited position of interfacing the machine with the learner. This thinking seems to have emerged because of two reasons. First, the systems approach, as employed in military and industrial settings, is usually featured as the means of maximizing the machine or nonhuman aspects of the system. Second, in order to describe the systems approch some form of flow chart is employed (see Figure 3). Flow charts look cold and formidable to the educator unaccustomed to reading them and perhaps connote a representation of something like an exactly prescribed electronics system flow.

The dehumanizing concern is unfounded. In fact, the systems approach provides the means whereby human interactions in the learning process can be enhanced. The systems approach is simply a guide for planning and developing the instructional program to achieve that which is desired. If the educator's goal, for example, is to develop a program that brings teachers into closer interaction with learners at a higher level than simple information giving, the systems approach helps the behavioral technologist organize the means for bringing that about. Many examples could be cited as evidence that our present educational practices place teachers in roles that are not very high on the human interaction scale; i.e., transmitting simple fact and information, scoring and recording grades, passing-out and taking-in papers, etc. The systems approach provides a potential power that permits the vision to say where human factors can be enhanced, and where automated, mechanical, or other procedures can better accommodate the other type things.

Without employing the systems approach to instructional development the goals of the educational industry will probably fall short of being completely achieved. It would only be by chance that maximum efficiency and benefit might be obtained from all elements of the instructional system in the accomplishment of the system's objectives. A systems approach provides not only the means for systematic planning, designing, organizing and controlling the development of instruction but then builds upon that which has been found to work best and eliminates those parts that contribute least or negatively to the desired goals.

Consider Figure 1. The box at the top of the diagram in Figure 1 represents some defined problem, at any level, in the educational industry which requires solution. Let's say the problem is to develop an instructional system that more precisely teaches English composition to tenth graders, reduces the number of teachers required, and shortens the learning time. At the lower position of the diagram are a series of circles representing entities or elements to be considered for inclusion in the instructional system, such as learner differences, conditions for learning, social custom, etc. The arrows indicate that some elements are either not appropriate to the solution of our English Composition problem or are constrained in such a manner as to be impractical for inclusion in the new system. For example, the circle labeled "learner characteristics" represents important characteristics of the learner that must be considered in the systems design. However, some learner characteristics may be inappropriate to include; e.g., height or weight. The point is, that prior to analysis we have no way of being certain which of the total array of elements should or should not be included in designing the new English Composition instructional system.

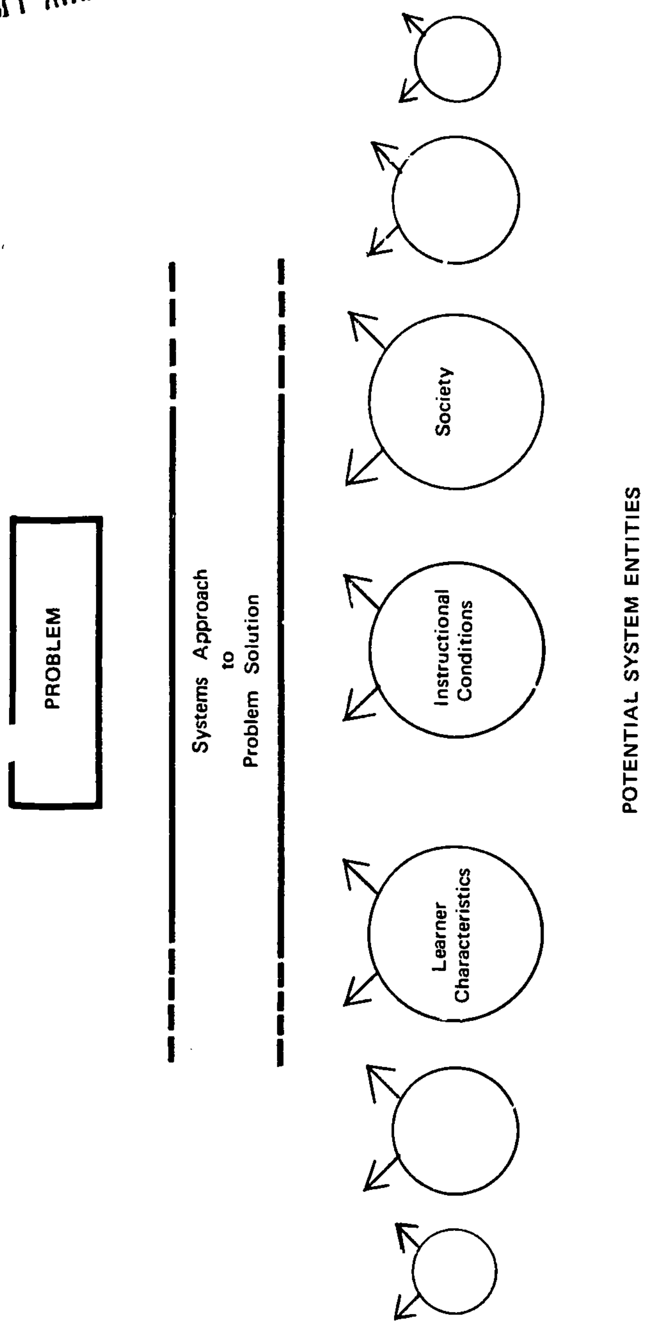

Figure 1. The place of the systems approach in the instructional system complex.

Central in the diagram in Figure 1 is an open ended box labeled "Systems Approach to the Problem Solution." The systems approach intervenes between the defined problem and the potential system entities. The systems approach then, becomes the means whereby, through systematic planning and analysis, a design linkage can be developed that relates performance limits and constraints of English Composition instruction with the essential systems elements. Continuing then, the design can become translated into instructional reality and through the iterative process of continuous and repeated evaluation the English Composition system reaches its maximum level of effectiveness.

One further thing regarding Figure 1. The ends of the box labeled "Systems Approach to Problem Solution" have not been closed. This is simply to reinforce the fact that there exists no single systems approach. It is unlikely that the same person will ever approach the solution of different problems in exactly the same way. Furthermore, there is a strong likelihood that the approach being employed at any one time may alter and shift during development.

Why systems approach? Because it is the most powerful and efficient means presently available for determining precise learning requirements and arriving at the most effective plan for eliciting the desired learning outcomes in an orderly fashion. It enables us, in the words of Meredith Crawford, "to separate the 'need to know' from the 'nice to know'" (1967, p. 6).

Systems Approach Applied to Instructional Development

A Fable

Once upon a time there were two pigs (a third one had gone into marketing and disappeared) who were faced with the problem of protecting themselves from a wolf.

One pig was an old-timer in the wolf-fending business, and he saw the problem right away--just build a house strong enough to resist the huffing and puffing he had experienced before. So, the first pig built his wolf-resistant house right away out of genuine, reliable lath and plaster.

The second pig was green at this wolf business, but he was thoughtful. He decided that he would analyze the wolf problem a bit. He sat down and drew up a matrix (which, of course, is pig latin for a big blank sheet of paper) and listed the problem, analyzed the problem into components and possibilities of wolf strategies, listed the design objectives of his wolfproof house, determined the functions that his fortress should perform, designed and built his house, and waited to see how well it worked. (He had to be an empiricist, for he had never been huffed and puffed at before.)

All this time, the old-time pig was laughing at the planner pig and vehemently declined to enter into this kind of folly. He had built wolf-proof houses before, and he had lived and prospered, hadn't he? He said to the planner pig. "If you know what you are doing, you don't have to go through all of that jazz," and with this, he went fishing, or rooting, or whatever it is that pigs do in their idle hours.

The second pig worked his system anyway, and designed for predicted contingencies.

One day the mean old wolf passed by the two houses (they both looked the same—after all, a house is just a house). he thought that a pig dinner was just what he wanted. He walked up to the first pig's house and uttered a warning to the old-timer, which was roundly rejected, as usual. With this, the wolf, instead of huffing and puffing, pulled out a sledge hammer, knocked the door down, and ate the old-timer for dinner.

Still not satiated, the wolf walked to the planner pig's house and repeated his act. Suddenly, a trap door in front of the house opened and the wolf dropped neatly into a deep, dark pit, never to be heard from again. Morals:

1. *They are not making wolves like they used to.*
2. *It's hard to teach old pigs new tricks.*
3. *If you want to keep the wolf away from your door, you'd better plan ahead.*

Roger A. Kaufman (1965, p. 1)

Through experience it has been learned that when an individual or department is given the charge and the opportunity to improve its instructional procedures it normally begins by doing more of what it is already doing. Most instructors believe they already know what they need to do to improve their courses, and all they need is sufficient time and resources to do what they have always wanted to do--and an approximation of the perfect course will result. Unfortunately, this approach has been tried extensively with the result that students are given the same content and the same ideas merely in a more elegant form, and the tragedy of this is, that empirical evidence has repeatedly shown that the more elegant form, and the more concentrated and sophisticated nature of the presentation, results in less learning by students. This is hard to accept. But, it is a consistent finding, and it has a rather firm psychological basis. The fact is that the requirements of the sophisticated learner (instructor) , and what satisfies him, are very different from the requirements of the naive learner, and what satisfies him. Some evidence indicates that the more sophisticated and informed the scholar, the less sensitive he is to the requirements of the naive learner. (Mager, 1963; Rothkopf, 1963)

Therefore, to merely afford a scholar more opportunity to prepare a course of instruction is not a sufficient condition, in and of itself, to insure the improvement of instruction. This weakness can be overcome through the application of the systems approach. Of course, we will need behavioral technologists trained in the systems approach to interact with and guide the untrained scholar in the instructional development.

The Major Stages of the Systems Approach to Instructional Development

The systems approach to instructional development is actually a series of interlocking steps that guide the behavioral technologist through the process. As a prelude to the complexities of the process, the model presented in Figure 2 shows the main stages of the approach.

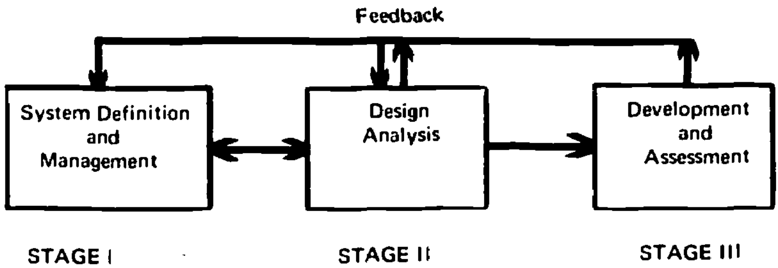

Figure 2. Major stages in a systems approach to instructional development.

Stage 1 in the systems development model is called *system definition and management*. This stage pertains to those start-up and load-in activities that must be planned and organized before the detailed tasks of designing and developing the actual instructional system can begin. Some instructional system models omit this level of activity and initiate the systems approach at Stage II shown in Figure 2: the design analysis stage. However, to omit the first stage fails to acknowledge the full potential of developing instructional programs.

The systems approach is a means of thoroughly planning and organizing for the systematic design and development of instruction. How one proceeds to set the stage for employing the systems approach to developing instruction should be as systematically planned, organized and conducted as that done in developing the new instructional system. During this stage, attention is directed to detailing what is required of the new system, the selection of technical and support people, the gathering of support information and materials and a definition of the context within which the system is to be imposed.

The second stage in Figure 2 is termed *design analysis*. This stage defines the techniques necessary for specifying performance standards, materials specifications, and design and operational constraints imposed by the educational industry. The two-way arrow in Figure 2 connecting the system definition and management box with the design analysis box indicates that information flows both ways. Management constraints will impose limitatins upon certain design elements. Similarly, analysis in the system design are apt to call for some shifts in management.

Stage III in Figure 2 concerns *development and assessment* procedures. During this stage the prototype of the instructional system is prepared including all necessary content, media and methods. Then the prototype must be empirically evaluated to determine the extent to which the system achieves its purpose. Corrective iteration of all aspects of development and evaluation is continued until the instructional technologist is satisfied with the validity of the new system.

A feedback line has been added to the model in Figure 2 to indicate that information gained in the development-assessment stage is important to input into both stages I and II as a means of providing some organized means of quality control.

Perhaps brief attention to what is meant by feedback would be helpful. As used in the context of this paper, feedback refers to information resulting from the activities of two or more elements in a system which, when returned to the system, provides a basis for making adjustments to the system.

For example, the sophisticated gambler, when initiating play against the novice, attends very closely to the beginner's vocal and bodily reactions. The information thus gained from the interaction between the gambler's and novice's actions (feedback) allows the gambler to adjust his subsequent play and probably "clean out" his opponent.

In a similar way feedback is used in modifying the development of a new instructional program. For example, consider Figure 3.

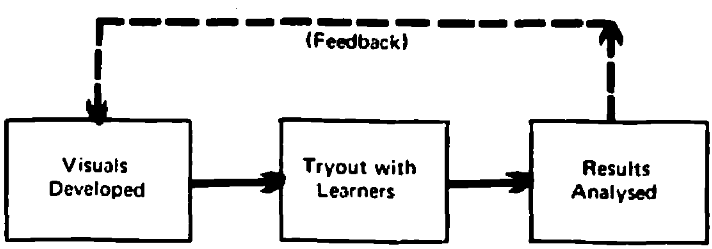

Figure 3. Feedback lines showing return of information to the system.

In the example, it is assumed that the instructional objectives and design specifications have been defined and the instructional technologist is in the process of developing specific visuals to satisfy these requirements. Following the development of several overhead transparencies the visuals are tried-out with learners of appropriate ability to test their effectiveness. The results are analyzed to determine weaknesses, which provides useful information (feedback) in making beneficial adjustments to the visuals. To the extent that careful attention is given to all possible details during try-out and analysis, maximum feedback is available to guide the modification of the visuals.

Specific Steps of the Systems Approach to Instructional Development

With the above brief overview of the major stages of the systems approach to instructional development, specific process of the systems approach will now be discussed step-by-step. Figure 4 shows the total configuration of steps. In the left margin are the three major stages that were presented in Figure 2. The steps in each major stage will be defined and related to that stage.

Step 1. Define instructional problem. The initial and perhaps most critical step of the systems approach is to complete a definition of the problem and the best estimate for its solution. This definition can only come about through the collection of information from the total setting in which the problem emerged. Change requires a fundamental modification of a system, a new alignment of elements, processes, or ways of interrelating. To change any part of the instructional system -- new course, modified course, change in organizational operation -- requires a consideration of what came before, and what will follow. We can no longer afford to engage in the process of modifying components of the educational system as if they were interchangeable; in changing any of the entities of the system we change the system-structure. Therefore, to the extent that the total system setting can be defined -- personnel, organization, instructional setting, support elements, philosophy, etc., it will increase the effectiveness of the subsequent development.

If the problem in question, for example, concerns the inability of particular groups of learners to acquire a specified level of competence in discriminating among certain classes of objects; then the more information that can be generated about that problem, such as the total setting of learners, instructor, methods, facilities, etc., the better chance to facilitate an effective solution. A tentative solution might already have been suggested - develop a set of visuals to replace the faulty chalkboard drawings of the teacher however, additional definition of the problem is apt to uncover other confounding factors.

Step 2. Determine and select support staff. As the problem becomes better defined and a tentative solution is determined, it is necessary to select subject matter experts, media specialists, and learning specialists to guide the development and assure the technical quality of the content.

Step 3. Determine management controls. At the same time of selecting support staff, management controls in the conduct of the instructional development need not be determined. Interfacing between

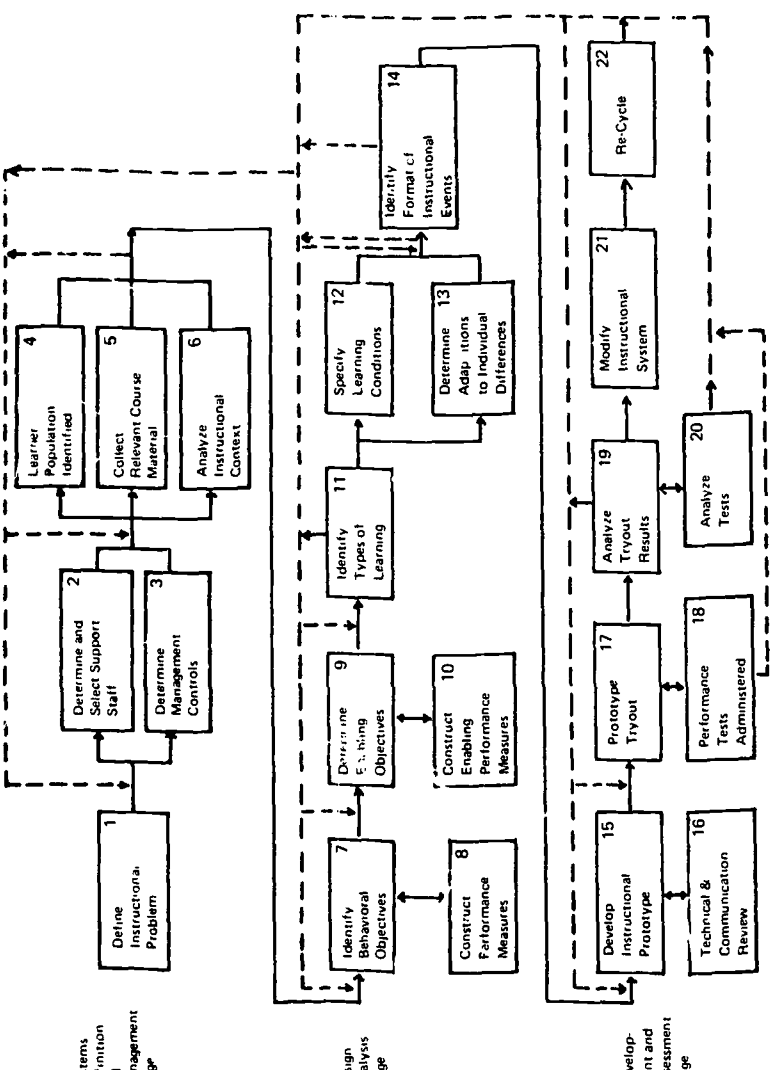

Figure 4. Flow diagram showing the specific steps of the Systems Approach in developing instructional systems

various support staff are necessary; communication flows essential to linking personnel and system elements should be identified; feedback routes to permit return data inputs must be planned.

This step serves in a two-way capacity: (1) management controls need to be determined for the lead-in activities that establish the organized setting required to carry out the system development; and (2) management of activities within the systems development must be determined, i.e., who is responsible for what functions, how does information get from one source to another, what alternative routines should be followed in the event that certain constraints emerge.

Step 4. Identify learner population. The students who are to participate in the new instructional system must be identified and all prominent characteristics determined. This is best accomplished by the instructor consulting with a behavioral scientist who is knowledgeable in individual differences. If the setting of the instructional system to be developed is to have any possible chance of being modified to adapt, as Professor Beaird puts it in his chapter, to salient and meaningful psychological differences in individuals, the learner population must be clearly identified. Hopefully, the discussion in this and later sections of this chapter will increase Beaird's efforts to create a cognitive dissonance in the reader regarding adaption of instruction to individual differences. If the reader feels that he must reduce the inconsistency between a positive attitude toward providing for individual differences and the behavior of failing to substantially do so, the techniques discussed in the systems approach could contribute measurably.

Step 5. Collect relevant course material. This step occurs concurrently with Step 4 and concerns the searching for and collecting of materials and information pertaining to how the course was previously taught: course syllabi, tests, media materials, descriptions of activities, references, etc. The purpose of this activity is simply to provide maximum input for making design decisions regarding objectives, types of learning, content.

Step 6. Analyze instructional context. Step 6 takes place at the same time that Steps 4 and 5 are being conducted. Here the concern is to identify and understand the relationships of all elements within the present instructional setting. To the extent that the context within which the new instructional program will be imposed is analyzed, problems of interfacing -- fitting together the various parts of the system -- and integration, will be reduced.

Thus far the steps of the first major stage, systems definition and management, have been defined These steps were (1) define instructional problem, (2) determine and select support staff, (3) determine management controls, (4) identify learner population, (5) collect relevant course material, and (6) analyze instructional context.

Brief mention should be made of the feedback lines among the steps of the systems definition and management stage. Inspection of Figure 4 indicates that outputs resulting from Steps 4, 5 and 6 are inputs to Steps 1 and 2 and Steps 4, 5 and 6.These feedback routines are to assure that maximum information is generated for the system design stage. As the behavioral technologist combines the outputs from learner characteristics, relevant course materials and relationships in the instructional context, new insights are apt to emerge for any one of these three steps that will result in additional definition to the system. Similarly, it might contribute additional insights in terms of seeking additional or different support staff and for organizing management controls in a more efficient manner.

Now we move to the second major stage of the systems approach, design analysis stage. Reference to Figure 4 shows that this stage consists of Steps 7 through 14. The line coming from Steps 4, 5 and 6 goes directly to Step 7.

Step 7. Identify behavioral objectives. From all that has preceded Step 7, behavioral objectives are made. A behavioral objective is a statement that says very precisely what changes in the learner's behavior are expected to occur as a result of the experiences provided him by the instructional systems. Now we get down to the critical step in the systems approach that, more than any other, determines what form and shape the development will take. The objective must describe clearly what it is that the learner must be able to do following instruction, the conditions under which he must be able to perform, and the standard or criterion of acceptable performance. It different terminal behaviors are planned for different types of learners, these must be clearly defined and specified. This chapter is not designed to teach the skills of actually writing behavioral objectives, however, two excellent sources are suggested to those who wish to pursue this task: (1) Robert F. Mager's *Preparing Instructional Objectives* (1962), and Casper F. Paulson's, "Specifying Behavioral Objectives" (1967).

At least three essential characteristics must be present before an objective can become useable in designing an instructional system, (1) the objective must represent some event or occurrence that is identifiable; (2) the conditions in the instructional system necessary to bring about the desired outcomes must be able to be controlled, and (3) the instructional designer must seriously intend that learners will achieve the objective.

Step 8. Construct performance measures. Simultaneous to determining behavioral objectives is the need to develop measures capable of assessing the performance specified in the objectives. Evaluation of the learner's performance is the fundamental purpose of constructing performance measures. Step 10 will discuss the development of other ssment instruments and how they differ with these measures.

By developing measures for assessing criterion performance at the same time as objectives are determined it eliminates the pitfall of assessing that which has been taught. It also requires that close scrutiny be made of the behavioral objectives which has the advantage of uncovering ambiguities or gaps in the objectives.

The primary function of these measures is to determine whether or not the expected behaviors were acquired by the learners as a result of the instruction. The issue of whether or not the instruments are valid for this purpose will not be given attention in the paper, except to say that a separate routine for determining test validity must be established. Discussion of this issue is provided by Schalock (1967). The reader is also referred to a publication by Parsell for discussion of the evaluation of large complex programs (1966).

Step 9. Determining enabling objectives. When all the terminal objectives have been prepared, then it becomes necessary to map out very precisely what specific things the student must learn in order to arrive at the terminal behavior. In other words, we must determine for each stage in the instructional activity what increments of knowledge, skill, or affect is essential to enable the learner to successfully take the next learning step and eventually arrive at the end point in instruction fully possessed of the desired terminal behavior.

The means for determining the enabling objectives is called objective analysis. This analysis of enabling or subordinate objectives is based on procedures used by Gagne and has often been referred to as hierarchical analysis (1962,1965). Basically objective analysis requires the behavioral technologist to start at the terminal objective and by successively asking the following question to back up until he has reached the prerequisite level of behavior: "What kind of capability would an individual have to possess if he were able to perform this objective (or sub-objective) successfully, were we to give him only instruction?" The resultant output creates a pyramid latticework with the terminal objective at the apex and the prerequisite type sub-behaviors leading downward toward the base. Figure 5 depicts this in graphical form.

The latticework in Figure 5 is only representative of that which results from the objective analysis task. It is necessary to generate a separate enabling lattice for each terminal objective. Unfortunately, we are only crudely able to accomplish such tasks in our present level of sophistication. To generate such a hierarchy is a highly complex task and confronts the behavioral technologist with identifications and discriminations of the highest order. Furthermore, in many instances no clear cut distinctions can be made regarding at which level a particular enabling objective emerges, what lines of relationship should connect it to other

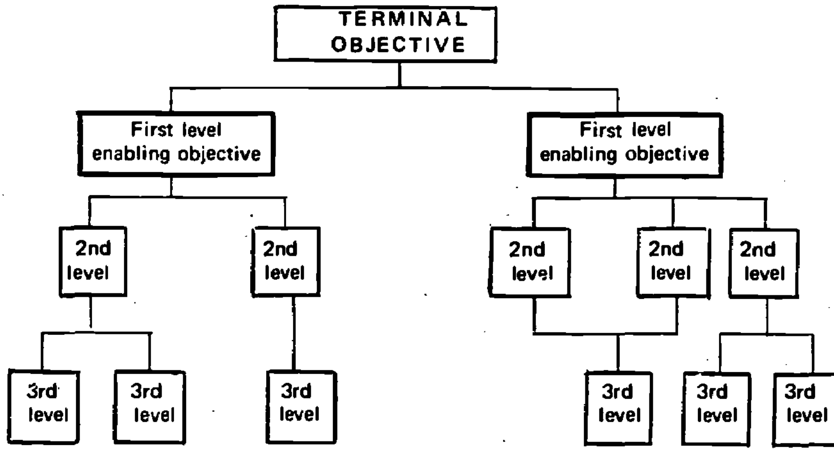

Figure 5. Hypothetical latticework of enabling objectives leading to a specific terminal objective.

enabling objectives, and even under which terminal objective it primarily belongs.

Attention to differences among the individuals for which the enabling hierarchies are designed would cause many different lattices to emerge. Hypothetically, it seems reasonable to assume that each individual learner should have his own hierarchy. This is, of course, impractical to consider, if not impossible. However, it would appear to this writer that if real adaptations of instruction that account for differences in learners are to be accomplished one place where systematic impact can be made is at the enabling objective level.

Step 10. Construct enabling performance measures. Concurrent with determining enabling objectives is the need to develop measures capable of assessing enabling performance. Evaluation of the learner's performance is, of course, one of the important purposes for constructing performance measures, which was discussed in Step 8. However, in the systems approach to instructional development, two other equally important purposes are served in constructing performance measures: (1) to determine to what extent the system is achieving its enabling objectives; in other words, validating the internal elements of the instructional system; and (2) to test assumptions upon which enabling objectives have been determined. Here again, the purpose of this paper is not to discuss measurement issues and the reader is referred to Schalock for further information (1967).

Step 11. Identify types of learning. An important link between instructional objectives and the conditions for producing the behaviors that achieve these objectives concerns what type of learning is to take place. For example, will it be identification, discrimination, concept learning, or problem solving? Unfortunately, one of the severe limitations in our present effort to create maximum learning conditions lies in not being at all certain of what type learning is required at each stage of the enabling lattice. Several efforts have been made to specify learning taxonomies that give some guide in this step (Cotterman, 1959; Miller, 1963; Gagne, 1965). Although these are still crude and imprecise tools, they do give us a starting point. In Chapter II of this manual, Dr. Schalock gives attention to the limitations of our present capabilities to identify types of learning and suggests a two-level taxonomy of learner outcomes as a more adequate base.

Step 12. Specify learning conditions. After identifying the types of learning represented in each enabling objective, the task confronting the systems designer is to specify learning environments which maximize the opportunity for learners to acquire the enabling behaviors. Obviously, conditions reflect instructional events and settings. This step involves translating the types of learning required in each enabling objective into a set of specifications that detail what conditions are essential. This step is perhaps as weak in technology as is Step 10. Only limited work has been done in this field of endeavor to guide the behavioral technologist. One such effort is the work of Gagne (1965). Obviously, as in Step 10, the challenge for adapting instruction to the differences of individuals is faced in Step 12. Until we can maximize the learning conditions to meet the specific needs of learners, only casual attention to their differences can be accomplished.

Step 13. Determine adaptations to individual differences. Although the techniques for making adaptations to account for individual differences are considerably limited, as has been briefly brought out in this chapter and more adequately detailed by Dr. Beaird in Chapter III, it remains for the behavioral technologist to be sufficiently challenged whether because of his cognitive dissonance or merely his concern - to strive for design specifications that aim toward the individual. Through empirical steps in the systems approach, the behavioral technologist can look systematically for factors that improve the opportunities for individual learners to maximize learning with the hope that scientific inquiry might eventually explain their relationships.

Step 14. Identify form of the instructional event. The selection of the specific form of the instructional event must next be determined. Decisions must be made whether they should be verbal, nonverbal or combinations thereof; whether to use visual or auditory forms; or whether they should involve tactical or olfactory senses; or some combinations of all the above. Obviously there are other considerations regarding requirements for motion or duration of exposure, etc.

Several guidelines are emerging to give the behavioral technologist some assistance in specifying these design requirements. For example, Briggs has set forth a procedure for design of multimedia instruction (1967). Although the examples are given at the kindergarten level, the steps shown have some generalizability to all levels.

Nunnelly, *et al.*, has established a set of criteria for selecting a methods-media baseline for training programs. He contends that if a behavioral technologist chooses, he "can select criteria which has documented and documentable validity and produce a system responsible to needs no matter what its ultimate configuration" (Nunnelly, 1966, p. 168). Although this is a rather strong claim, the criteria do appear to offer some facility. Nunnelly's criteria are presented in Figures 6 and 7.

Another useful categorization is offered by Hamreus as a guide in deciding what stimulus elements are to be used in the instructional system (1967). Although there is conflicting evidence regarding the sensory mechanism and the nature of the learner interacting with more than a single class of stimuli in a particular situation, this model does present classes of sensory cues into some meaningful identifiable dimensions. Step 14 completes the second major stage – Design Analysis – of the system approach presented in Figure 4. During this stage all performance specifications and design criteria for the development of the instructional prototype are completed. Similar as before, feedback lines are drawn among the various steps of the second stage that also lead back to the first systems approach stage. These lines designate outputs resulting from design analysis steps which provide inputs to various other places in the network.

The final major stage of the systems approach to instructional development concerns development and assessment of the instructional prototype and includes Steps 15 to 22.

Step 15. Develop instructional prototype. At this point development work is begun on the instructional content, media, equipment designates and instructional sequences. It is essential that development of the instructional prototype adhere closely to the design specifications generated in the preceding stage. Content must be formed into messages - visual and or auditory, and arranged in sequences designed to accomplish behavior changes. Formats for each selected message element must be established for each aspect of the content; i.e., which printed statements are to be hand lettered and or typed and enlarged; whether to photograph real objects, caricatures, or abstract symbols; whether to use black and white or color; exactly what content elements go first and which follows; what form the transitions or interfacings between elements should take; how specific learner actions or routines should be introduced; exactly

1. Learning Identifications
   - Simulator
   - Part-Task Trainer
   - Mock-up
   - Television
   - Moving Pictures
   - Still Pictures
   - (Recorder) Aural Only
2. Learning Perceptual Discriminations
   - Simulator
   - Part-Task Trainer
   - Mock-up
   - Television
   - Moving Pictures
   - Still Pictures
   - (Recorder) Aural Only
3. Understanding Principles & Relationships
   - Animated Panels
   - Television
   - Moving Pictures
   - Still Pictures
   - Recorder
   - Programmed Instruction
   - Lecture/Discussion
4. Learning Procedural Sequences
   - Simulator
   - Part-Task Trainer
   - Television
   - Moving Pictures
   - Still Pictures (Sequenced)
   - Recorder
   - Programmed Instruction
   - Lecture/Discussion
5. Making Decisions
   - Television
   - Moving Pictures
   - Still Pictures
   - Recorder
   - Programmed Instruction
   - Lecture/Discussion
6. Performing Skilled Perceptual-Motor Tasks
   - Simulator
   - Part-Task Trainer
   - Mock-up

Figure 6. Training Objectives/Human Performance Data (Nunnelly, 1966).

LEVEL I: Requires simple identification of components; understanding of discrete perceptual, motor and/or perceptual-motor behavior segments.

1. No emphasis in operational integrity
2. No requirement for high simulation fidelity
3. Low order of task complexity
4. Learning objective:
   a. Awareness
   b. Discrimination

LEVEL II: Requires learning of specific procedures using equipment which represents operational configuration. Emphasis on orderly sequences, parts relationships, test, etc.

1. Emphasis on feedback for test
2. Emphasis on positive transfer to real equipment requirements
3. No high simulation fidelity for internal operations of trainer to aircraft
4. Learning objective:

Prerequisite a. Awareness
b. Discrimination
New c. Application within established order with self-initiated strategies

LEVEL III: Task specifications requires learning of single sets of tasks which represent only part of total operational requirements. Emphasis on operational integrity for maximum transfer to real world.

1. Emphasis on system operational identical to aircraft operation
2. High Simulation Fidelity
3. Emphasis on continuous feedback and system integrity for trainer
4. Higher order of task complexity:
   a. Self-initiated responses based on continuous changing of S-R components
   b. Responding to a variety of S-R configurations , requiring immediate and unique response modes
   c. Real time continuous for operation model
   d. Learning objective:
      (1) Awareness
      (2) Discrimination
      (3) Procedure Application
      (4) Application of analysis, and decision-making commitments (problem solving strategies)

LEVEL IV: Task Specifications requires learning of total operational task as required for actual full operation of aircraft.

1. Highest simulation fidelity
2. Total feedback-response cycle required for aircraft operation in all normal emergency modes
3. Highest order of task complexity
4. Learning Objective: Total operational proficiency for subsystem (Analysis, application, etc., through correct decisions at appropriate time, using correct procedures and correct problem-solving strategy to achieve stated measure objective for aircraft).

Figure 7. Training and Selection Criteria and Task Specification (Nunnelly, 1966).

when and how the teacher is to interact in the learning situation. These are suggestive of the development decisions that must be made. Obviously, instructional development will not have neat and firm design specifications to guide all aspects of prototype development. To the extent that the behavioral technologist can keep careful record of such developmental decisions and attend systematically to causal factors that produce particular effects, his skill at developing design criteria will be increased.

Step 16. Technical and communication review. Simultaneously with development should come rough draft review of content by discipline and communications experts. Considerable saving in time and expense result from this accuracy check.

Step 17. Prototype tryout. When technical and editorial requirements have been satisfied, an empirical tryout of the prototype system is required. A sample of students representative of the target population is actively engaged in a learning situation with the prototype system. All pertinent elements of the prototype system must be engaged, although it is not necessary during first trials to have all aspects of the total system completed as long as intact segments are used. Eventually, however, the total system must be tried out in the classroom setting with all real constraints.

Close observation must be maintained during early tryouts to produce maximum feedback. The learners are instructed to cooperate in this process by identifying any places that are confusing or uninteresting. Careful record of the referent of all such comments should be kept along with any other significant occurrences during the tryout not reported by the learner; i.e., puzzled expressions, evidence of boredom, undue time taken, etc.

Step 18. Performance tests administered. Concurrent with prototype tryout is the administration of performance tests to assess how well the system is actually accomplishing its objective at the completion of tryout, performance measures to assess terminal behaviors are administered. Attention should also be given to test administration routines to determine their appropriateness.

Step 19. Analyze tryout results. When all data from prototype tryout have been collected, analysis is conducted to determine where weaknesses exist in the instructional prototype. A second purpose of analysis is to ascertain whether enabling objectives were improperly and or unrealistically established and require change.

Precise analyses of the instructional system under development are not possible. In general, all things are new - the instructional materials, the routines, the measurement instruments. Analysis of this type relies upon empirical evidence of whether the desired or expected outcomes were observed. That is, did the learner do what he was supposed to successfully; was the teaching strategy adequate; were the interfacings of various elements functional? If observation shows faults in these elements, the question "why" must be pursued. Often the fact of noting the fault will bring a new perspective to the behavioral technologist and result in clearer realization of the causal factor. In other circumstances, only a slow and systematic exhaustion of possible alternatives can bring the desired insights. In some instances, insight might not occur.

Step 20. Analyze tests. Similar to analyzing the prototype tryout, measurement instruments are subjected to analysis. Do they indeed measure the behaviors being taught in the system? Analysis must ascertain whether the tests are indeed valid for the purpose designed. Six criteria deemed essential in determining the validity of measures such as required in instructional development are the following; (1) the relevance of the measure in terms of what it is supposed to measure, (2) the representativeness of the measure, (3) its fidelity, (4) its reliability, (5) its accuracy, and (6) its practicality (Schalock, 1967, p. V-19).

Step 21. Modify instructional system. Analysis based on terminal performance specifications and individual and group validations suggest modifications to the instructional system. Feedback from all aspects of the systems approach flow are utilized to input necessary modifications.

Step 22. Re-cycle. The final step in the systems approach is a re-cycle of the total developmental process until desired outcomes of learner behaviors are achieved. Re-cycling is not fixed to any particular step but rather depends upon feedback information to designate which step(s) would result in the best pay-off. When this corrective iteration is complete the instructional system is ready for implementation into the "real educational world."

'Reader's Digest' Version of the systems approach

The twenty-two step maxi-model just defined represents the elements of a major development approach. It assumes an instructional development team, support personnel and facilities, time and dollars. It is systems application at an optimum level.

To the individual behavioral technologist in an educational situation with limited assistance and support, this maxi-model is perhaps complex and might seem beyond reach. The following section gives an adapted version of the larger model cut to a mini-system or "Reader's Digest" version which still maintains intellectual integrity. Figure 8 shows the six-stage flow diagram of the mini-model.

Box A. Problem Definition. As in the maxi-model, the start point is to take stock of the nature of the problem and the setting within which it has emerged. The instructional technologist must answer questions such as the following: What exactly is the instructional problem in its broadest sense? What has caused this problem to be felt? Who are the principal persons associated with the problem (instructor, administrator, AV

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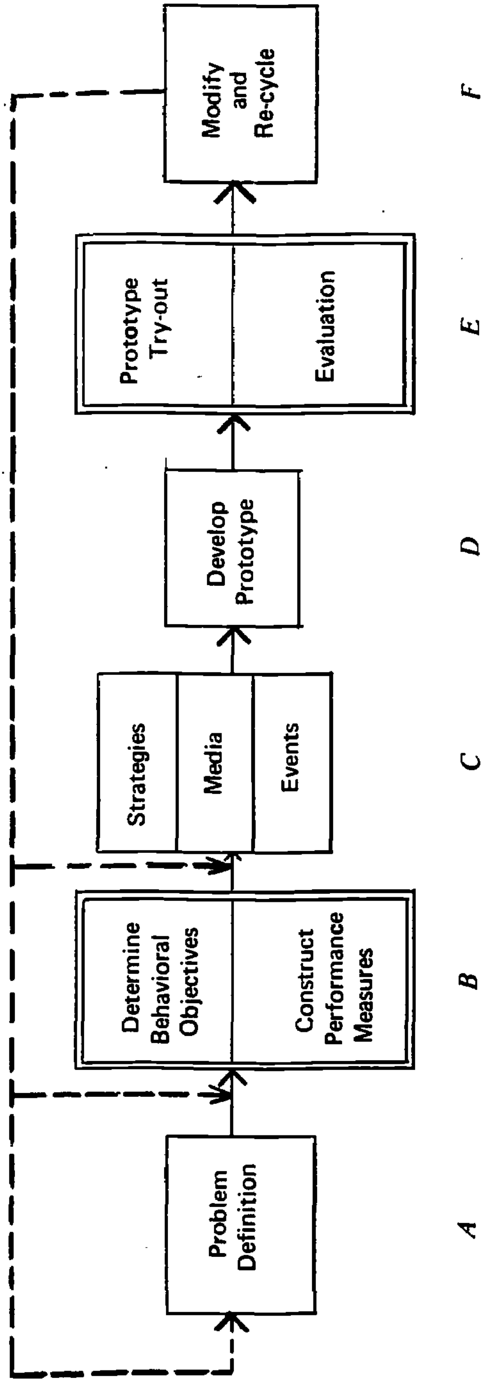

Figure 8. Mini-system flow diagram for developing instructional systems.

specialist, etc.)? What are the salient characteristics of the learner population (grade level, reading abilities, interests, etc.)? What resource materials are available to the problem (course syllabi, tests, research reports, etc.)? What constraints might there be (cost, time, space, etc.)?

Box B. Determine Behavioral Objectives; Construct Performance Measures. These boxes have been outlined with a double line to impress upon the reader the importance of this activity. A separate behavioral objective must be written for every behavior the instructor wishes the learners to acquire as a result of the instruction. This is a most critical step; one in which all other phases of the development depend. Three essential elements must be included in each behavioral objective statement. The performance expected of the learner must be clearly stated in a measurable form; the conditions under which the performance is to be shown must be identified; and the degree of acceptable behavior must be determined (see Step 7 for further discussion of behavioral objectives).

The second part of Box B concerns the development of tests which will measure the behaviors identified in the above objectives. The behavioral technologist's success in evaluating his instructional development (Box E) will depend upon the extent to which these tests actually measure the intended behaviors (see Step 8 for additional discussion of performance measures).

Box C. Strategies, Media, Events. Although this box is divided into three sections for purposes of clarity, all three are parts of the whole and take place simultaneously. Strategies refer to plans for selecting and presenting subject matter content--what specific content, level of language, sequence of statements, etc. Media refers to the form of media to be used in conveying the content--printed matter, slides, audio tapes, etc. Events refers to the activities in the instructional environment which produce the interactions of learners; teacher and materials necessary to bring about desired learning outcomes.

Box D. Develop Prototype. Outputs from Box C will provide working specifications for developing the instructional prototype. Substance must be provided these specifications in the form of printed materials, visuals, auditory or combinations thereof. A teacher manual is usually required to provide a detailed set of instructions for employing the new instructional program.

Box E. Prototype Try-out; Evaluation. This box has been doubly outlined like Box B to stress its importance. Box E represents a quality control measure built into the developmental process. The instructional prototype must be tried with representative learners in a realistic instructional situation. Learning outcomes must be assessed with performance measures developed in Box B as a basis for evaluating outcomes. In addition, attention must be given to other evaluative details; i.e., evidence of boredom, anxiety, confusion; poor teaching routines, etc.

Box F. Modify and Re-Cycle. When the prototype has been evaluated, it must be modified to account for the weaknesses identified. This modification must take place in the context of all preceeding information gained in Boxes A - E. In other words, evaluation data must re-cycle through the other boxes in the flow diagram so that modifications are made with the full advantage of all possible information. The modified instructional program is then re-tried and evaluated and the whole process repeated until the behavioral technologist is satisfied with the outcomes.

Examples of Other System Development Models

Three different systems development models will next be presented to give the reader a glimpse of other approaches. It should not be concluded that these three models necessarily are representative of all types of system development models.

The three models to be reviewed will be referred to as the HumRRO, Tracey, and Michigan State models.

The HumRRO model. HumRRO is the acronym for Human Resources Research Office of George Washington University. HumRRO has made significant contributions to systems applications to education; however, their principal effort has been directed toward training programs.

The HumRRO model more accurately represents a synthesis of several models developed by HumRRO, and concerns itself primarily with communications both within and without the training facility.

The diagram in Figure 9 represents the HumRRO systems approach to training programs. It illustrates the major elements that go into developing a training system.

The major deficiency of the HumRRO model is in the limitation of detail and the lack of emphasis on communication between elements.

The Tracey model. More accurately, this model might be referred to as the MINERVA model, since its development was initiated around the development of a U.S. Army instructional systems model which had the project name of Project MINERVA. It was a comprehensive management program to analyze and renovate the total training effort of the U.S. Army Security Agency Training Center and School. The senior leader of the development was William R. Tracey; thus the present name of this model.

The primary objectives of the Tracey model were to design, develop, and validate an instructional system which would train personnel more precisely for the technical duties they were to perform in field units, reduce the number of instructors and support staff needed for training, shorten training time, and lower overall costs. The ten stage systems design of the Tracey model is shown in Figure 10.

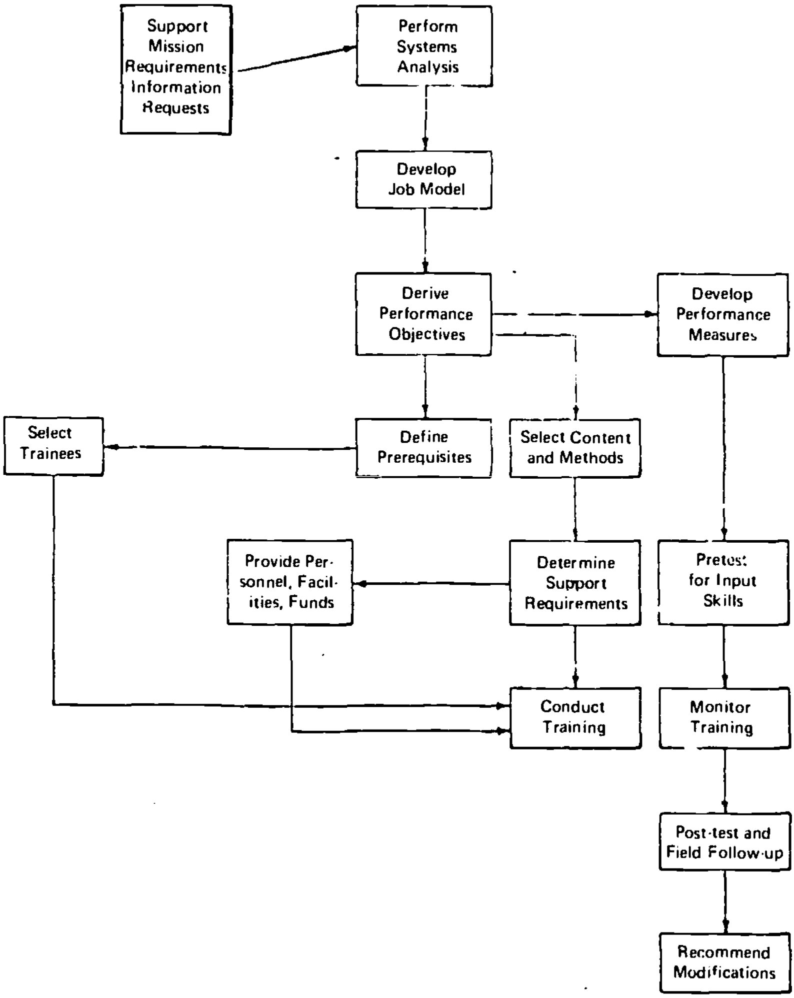

Figure 9. HumRRO Training System Development Model

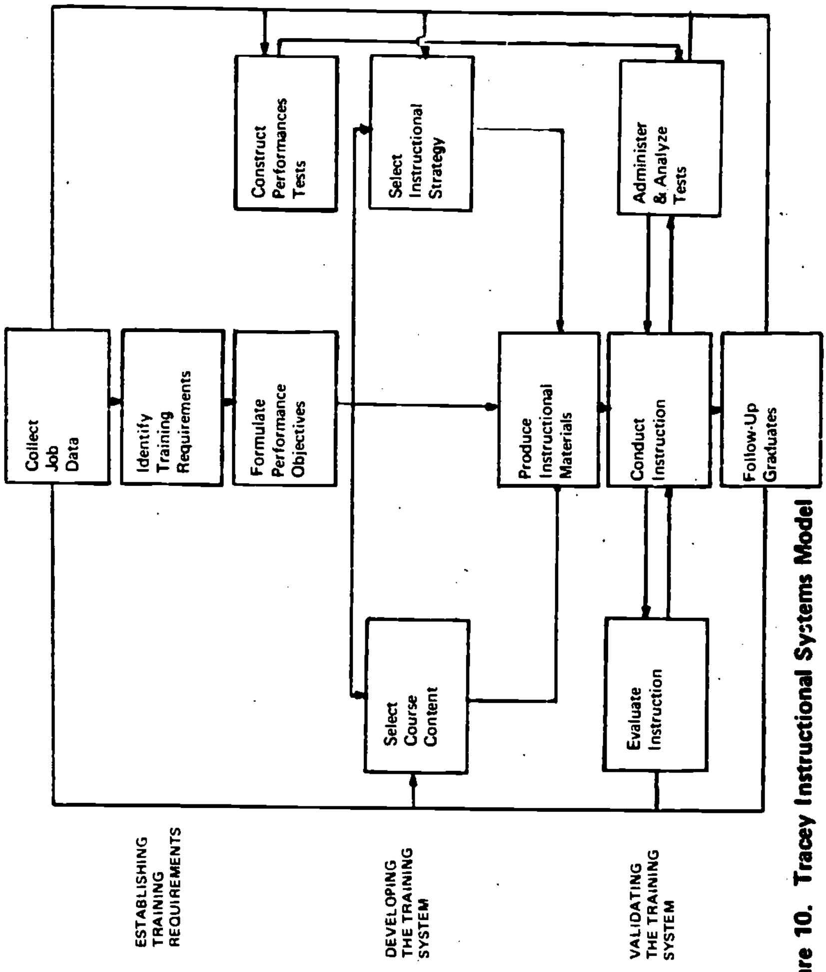

Figure 10. Tracey Instructional Systems Model

The major weaknesses in the Tracey model are (1) its failing to consider the management and control of the context within which the training program is to be imposed, and (2) its omission of determining and enabling and prerequisite skills essential to attaining terminal performance.

The Michigan State University model. The last model to be defined is referred to as the Michigan State University model. This model was developed in 1963-65 as a hypothetical model for systematic development of college-level courses. Certain assumptions about the model were tested in a two-year study of instructional development in the following four major institutions of higher learning: Syracuse University, Michigan State University, the University of Colorado, and San Francisco State College (Barson, 1967). Figure 11 shows the Michigan State University model.

The Michigan State University model shown in Figure 11 fails to come to grips with the issue of identifying enabling objectives in the design stage. Even though we do not as yet have a theory of instruction, as Professor Schalock points out, we are able in part to identify types of learners, learning conditions, and forms of the instructional event that can take us a long way beyond our hunches or best guess gained through experience.

Heuristics of instructional development. In the course of developing and refining the steps in the Michigan State University model, the project team learned "how" to use the model in getting their desired results. These "hows" have been set down as a set of heuristics which the writers consider are "what has been learned by successive discovery—*action research* to guide future action." Eighteen heuristics were defined and are briefly summarized below (Haney, 1968).

Heuristic 1: Always move toward determining the professor's objectives. When a professor objects to spending time writing behavioral objectives, start by asking to see his exams or observe in the classroom, then deduce the different objectives and see if the professor agrees.

Heuristic 2: The development of software is dearer than the acquisition of hardware. It is in software development and utilization that the employment of hardware succeeds or fails.

Heuristic 3: The development of software is a continuous process. The production of validated instructional materials involves a commitment to continuous refinement and improvement.

Heuristic 4: Involve the student in the developmental process. The student is the prime source of information about the effectiveness of instructional materials achieving their objectives.

Heuristic 5: The model of instructional systems development is universal in only a general way. Each person using the model adapts it to

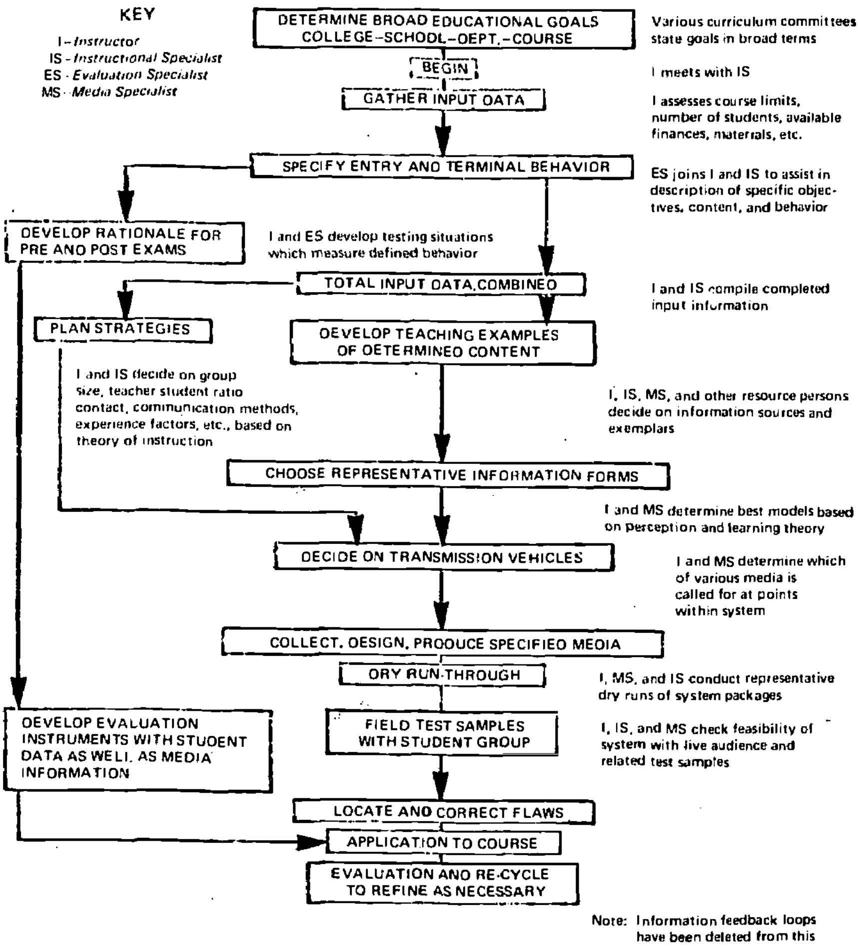

Figure 11. Michigan State University Instructional Systems Procedure Model.

his own situation but tends to employ the same general sequence of inter-dependent functions.

Heuristic 6: Stress the human elements in an instructional system. It is important to stress that your objective is the enhancement of human values and that there are distinctive roles and functions for humans in instructional systems.

Heuristic 7: Proceed on the basis of agreements. When working with multiple-section, multiple-instructor courses, it is important to get agreements as far as possible on procedures, criteria, objectives and grading instruments.

Heuristic 8: Don't let the words get in the way. An instructional development specialist using his own technical jargon may find that the teaching member "turns him off."

Heuristic 9: Seek out the dirty jobs. Find out the jobs departments want done, then move in and help them. Handling convention and conference support, preparing brochures, providing artwork for research reports are some. Be superbly responsive and proficient.

Heuristic 10: Learn the professor first. The students taking a course do this; so should the instructional development team.

Heuristic 11: See that faculty members are rewarded for work in instructional development. The normal academic reward system is stacked against a professor who spends the required long hours and energy developing validated instructional materials. The instructional developer is on solid ground when he establishes that the production of validated instructional materials is visible, quantitative and qualitative.

Heuristic 12: Structure the conditions for survivability. Instructional development projects have a high mortality because the energy to continue them often runs down in a couple of years, which is the time it usually takes publicity about an innovative project to circulate.

Heuristic 13: Structure the conditions for transferability. It is often very difficult to get one university to use another university's instructional materials. Ideally, the new instructional system should be packaged - materials, objectives, teaching examples, and demonstrations - so that another institution can examine, select, arrange, adapt, combine, and put the local label on the package.

Heuristic 14: Don't let subject matter interfere with an understanding of process. Let a professor study examples of a new instructional system or process in a discipline other than his own so that he will not become embroiled in content controversy.

Heuristic 15: When you abstract reality you also reduce the learning experience. The point of this heuristic is not the insufficiency of simulated or mediated instruction, but the necessity to bring the student from simulation to actuality as part of the structured learning activity.

Heuristic 16: Find the pattern or format that will balance benefits *and liabilities.* In an introductory course in business administration, you might invite a business leader to address a class and videotape his remarks for subsequent presentations. The results will almost invariably be the reading of a public relations speech. Instead, the TV interview format can be used to strip the guest of his PR armor and get him to focus directly on the issues related to course content.

Heuristic 17: Faculty members are not generally moved to change their behavior by reading reports of instructional research. A professor, student, or administrator will accept a change when it produces a perceived net gain from his own point of view and on his own terms.

Heuristic 18: Nothing persuades like a visit, but watch out–nothing deflates like a deluded visitor. Sometimes publicity about a particular activity raises expectations higher than can be supported by actuality.

The authors contend that the above heuristics are the mark of experience and do not conflict with formal preparation in theory and methodology. Although they offer many good, practical suggestions, they fail to provide any specific skills by which the instructional technologist may be guided in the developmental process. In addition, heuristic 15 -- when you abstract reality you also reduce the learning experience -- is of dubious value. Research has shown that with certain learners in certain learning situations the overwhelming array of stimuli emerging from the real world retards the efficiency of learning, whereas the controlled simulation of selected aspects of reality enhance learning.

Gaps In Current Systems Approach

One significant gap exists in the systems approach to instructional development presented earlier in Figure 4. Although the gap is recognizable, the techniques for attempting to bridge it are as yet extremely crude. The gap I speak of is that of translating enabling objectives into instructional events specifications. Put another way, no systematic method presently exists which permits instructional technologists to make decisions regarding what the nature of the instructional events should be to most effectively achieve the desired outcomes, i.e., should they be verbal, non-verbal, visual, or auditory, various combinations of these, etc.

It must be recognized that even with the limitations of our present methodologies for developing instructional systems, large numbers of learners are continually being educated and eventually become proficient in their jobs. This may, in large measure, be due to the fact that, under almost any conditions, people will learn if they are sufficiently motivated to do so. The point to keep in mind here, however, is that ineffective instruction can result in high between and within individual variability, which in turn will reduce instructional system reliability; it may produce performance incapabilities under certain conditions; and it can be very expensive. To surmount these problems instructional development cannot remain in the "art"-only stage but must be based on more systematic and reliable principles.

Various approaches to bridge the gap. A variety of task analysis methods have been developed, principally for military training purposes, that provide some usefulness for categorizing performance for the purpose of designing training programs. Although these approaches have not proved sufficiently successful to adequately bridge the gap in question, they do extend our capabilities in that direction. Two methods will be briefly summarized. Other references will be cited for the reader who wishes to pursue the topic further. The two methods to be summarized will be the techniques of R. B. Miller (1960) and Demaree (1961).

R. B. Miller's Method. Miller's methods of determining training media, such as technical manuals, specialized trainers, complete simulators, or operational equipment, consists of first listing the tasks required in the performance of the job. These tasks are then translated into behavioral activities. What follows next is to sort tasks into groups that call for common performance.

Miller then creates a matrix by listing the common groups of tasks across the top and by listing down the side the types of training or learning phases represented among the tasks.

Having established a matrix, Miller finally blocks out areas in the matrix "to indicate tasks and training phases that seem practical to incorporate into individual side and or devices." (Miller, 1960, p. 14).

Miller offers a step by step summary of the procedures to accomplish the above matrix. He provides an example in his Appendix in which he indicates the need for film strips, movies, and sound recordings to be used as instructional media. Unfortunately, he never explains on what basis these media were selected as distinguished from many other media. The gap between requirements and instructional events and or media appears to be bridged no less intuitively here than in less systematic developments.

R. G. Demaree's Method. Demaree attempts to bridge the gap of determining instructional events with his guide for implementing military specifications on training equipment development (1961). His report describes and explains the intent and scope of the sections which make up the Air Force equipment criterion document. Most of Demaree's discussion deals with the information necessary to and the procedure for completing training equipment requirement data and training equipment selection data. He first establishes what is termed the functional requirements and later the equipment needed to achieve the functional requirements.

Like Miller, he develops a list of behaviors within several stages of training from which he generates the functional requirements. Demaree uses a tabular rather than matrix form for this operation. He then codes each of these functions against ten established effectiveness characteristics of training equipment. Unfortunately, he does not explain the basis for establishing the particular categories used.

Demaree documents considerable information to be used in making the choice among specific equipments, which is not employed by Miller. He includes such things as trainee's qualifications, orientations, responses, and attitude toward equipment. Although Demaree's method results in more data than does Miller's, just how the application of the method including the "extra" data relates directly to characterizing the functional requirements of the training equipment is not made clear, and it appears that here, too, the final choice is one of the intuitive trade-offs and decisions.

Most of the work of men writing on methods of task analysis for training equipment requirements have perpetuated, until recently, behavioral categories derived from *a priori* and logical category systems without defending their use in application. Examples of other methods include Willis (1961), Parker and Downes (1961), and Folley (1964). More recently, newer efforts have been attempted to adapt information-flow categories (E. E. Miller, 1963) and categories based on learning principles (Fitts, 1964).

Issues in Systems Approach to Instructional Development

1. Can a widely generalizable task analysis format ever be developed? One that applies to any situation?

2. Can adaptation of instruction to individual differences be made at the enabling objective level?

3. Can the principles and techniques used in weaponry development and industrial production be modified to apply to educational systems?

4. Will the systems approach to instructional development dehumanize instruction?

5. Can a two-dimensional taxonomy of types of learning and instructional events ever be developed to permit the systematic development of instructional systems?

6. Is the systems approach to instructional development heuristic or scientific inquiry?

7. Does the answer to 6, above, make any difference?

8. Can education in general afford to develop the capability of employing the systems approach to instructional development?

9. Is the systems approach to instructional development in conflict with the IMC (Instructional Material Center) idea?

10. Is there a limit in size of instructional problem where systems approach is no longer an appropriate methodology, i.e., problem?

11. Is the systems approach applicable to the affective domain?

12. Does the systems approach to instructional development allow for creative use of the art of teaching?

13. Is the systems approach operable if certain relevant variables are overlooked?

14. Does the systems approach build in more complexity than is necessary?

15. Can the systems approach be employed as well in a closed system as in an open system (Halpin's definition) ?

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Learner Outcomes, Learning Processess and the Conditions of Learning

H. Del Schalock

Focus

As indicated by its title the present paper has as its focus learner outcomes, e.g., concepts, principles, skills, personality characteristics; learning processes, e.g., information selection, transmission, storage, transformation and retrieval; and the conditions of learning, that is, the materials and procedures used in the process of instruction. These are viewed as three of the five sets of factors which have to be considered in providing any instruction-learning experience, whether it is in the form of a casual, relatively unplanned experience such as a parent helping a child discriminate between a cat and a dog or a formal, carefully planned experience such as a teacher managing an instructional system designed to develop mastery over plane geometry.The other two sets of factors that need to be considered in designing learning experiences are learner characteristics, e.g., stage of intellectual development, experimental background, cognitive style; and setting characteristics, e.g., teacher characteristics, physical characteristics of the classroom and building or district policy regarding educational objectives or classroom management. Dr. Beaird's paper focuses upon these latter two sets of factors. The basic assumption underlying this and Dr. Beaird's paper is that the task of instruction is to bring about a maximal fit between these five sets of variables at any given point in time: the conditions of learning must mesh not only with what is known about the process of learning, but also with the learning outcome being pursued, the characteristics of the learner that is receiving the instruction and the nature of the setting in which the instruction-learning process is taking place. Figure 1 represents a schematic presentation of the relationship between these factors.

The purpose of the present paper is to summarize the various positions taken in the behavioral sciences with respect to learner outcomes, learning processes and the conditions of learning, develop a series of conceptual frameworks which synthesize these views, and then spell out the implications of these frameworks for the technologist committed to the development of instructional systems. In this sense the paper is seen, along with Dr. Beaird's, as a necessary supplement to Dr. Hamreus' paper, for it provides the knowledge base that is needed to pursue effectively and efficiently the various

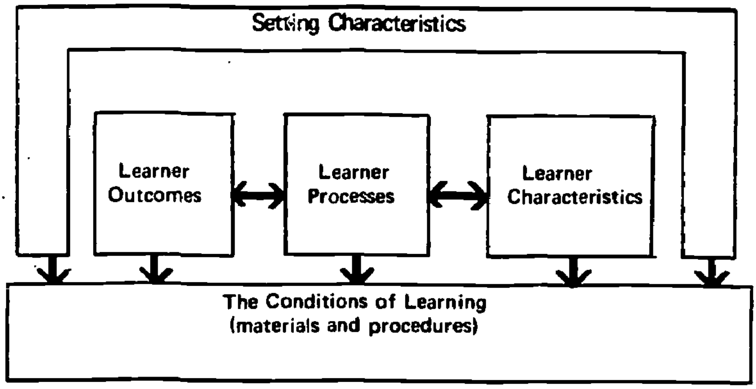


Figure 1. A schematic organization of the variables that need to be considered in the design of instructional experiences.

steps outlined in the DESIGN ANALYSIS STAGE in the development of instructional systems (see steps 7 through 13 in Figure 3 of Dr. Hamreus' paper). Without sound information to guide these decisions the systems approach has to depend upon hunch, experience and informed guesses as to how to proceed and the iterative recycling of approximations to an instructional system until the system finally reaches the point of producing the learning outcome that it is intended to produce. While it is possible to develop instructional systems that produce their intended outcomes in this way it is not a particularly efficient procedure. Moreover, there is no way of knowing whether the system that finally is produced is maximally effective in bringing about the learning outcome for which it is intended. For these reasons a basic assumption underlying the present institute is that a designer of instructional systems must be aware of the information that is summarized in this and the next paper.

Ideally, the information to be summarized in these two papers should provide a definitive set of prescriptions that an instructional technologist could use in designing an instructional system that brings about a given outcome for a given set of learners under a given set of situational conditions. Unfortunately, this kind of information is not available, and instead of offering a set of prescriptions that are in any way definitive of the interaction between the five sets of factors that need to be considered in the design of instructional systems *the papers represent essentially an ordering of the variables that need to be systematically related to one another in order to arrive at such prescriptions. In this sense the papers represent a basis for the development of a science of instruction as much as they do a compendium of information that the instructional technologist can use at this point in time.* Thus, while much of that which is reviewed in these two papers is not directly applicable to the task of the instructional technologist it is critical that the technologist be aware of this information for out of it must grow the science of instruction upon which the technology of instruction ultimately rests.

Generally speaking, the point of view taken in the present paper with respect to a science of instruction is that the behavioral sciences have generated a great deal of sophistication and methodology that is relevant to the development of a science of instruction but that they have done relatively little toward the development of a science itself. Psychology has focused upon learning and learner characteristics; sociology upon organizational structure, group processes and the ecology of the classroom; and anthropology upon the role of cultural differences in the learning process - all of which are critical to instruction - but nowhere has there been a concerted focus upon the instructional process per se. Central to my thinking about a science of instruction a distinction between *learning* and *instruction:* theories of learning deal with the ways in which an individual learns, theories of instruction deal with the ways in which an individual influences another to learn (Gage, 1964). In a sense such a distinction is arbitrary, for the end point of both is learning. In another sense, however, it is not, for the focus of one is upon the *processes* of learning and the other upon the *conditions* of learning. By forcing the distinction, and then attending systematically to the conditions of instruction, issues that tend to be obscured when focusing upon learning come into full view; for example, the dependency of instructional decisions upon educational objectives and learner characteristics. In their pursuit of laws governing learning, experimental psychologists have not attended systematically to either of these classes of information, and as such have failed to contribute significantly to the practice of education (Bruner, 1966) (Estes, 1960) (Gage, 1964) (Hilgard, 1956) (Gagne, 1965, 1967). The assumption underlying the present effort is that by highlighting the instructional process, and by attending to it both conceptually and empirically, it will be possible in time to develop a productive science of instruction which, in turn, will permit an effective and efficient technology of instruction.

The present paper is organized into three major sections: Learner Outcomes, Learning Processes, and The Conditions of Learning. Within each of these sections three tasks are undertaken: 1) a brief review of that which is known about the topic, 2) the development of a conceptual framework which synthesizes that which is known and organizes it for effective use in instructional research and development, and 3) the drawing of implications from (1) and (2) for instructional systems design. At the close of each section issues that appear critical with respect to the contents of that section are made explicit.

ISSUE 1: Can the distinction legitimately be made between theories of learning and theories of instruction? If it can, what are some of the implications for the field of education? If it can't, what are some of the implications?

ISSUE 2: Irrespective of the correctness of the distinction between learning and instruction, are the major variables to be considered in instruction appropriately identified in the present paper? Are there others?

ISSUE 3: Assuming the validity of the analysis of factors that need to be considered in instructional research and design is there any real hope of working with this many variables simultaneously in either a research or teaching setting.

Learner Outcomes

Central to the provision of any effective instructional experience is clarity as to the outcome one wishes to obtain as a consequence of the experience. This article of faith rests upon the assumption that instructional decisions are inseparably linked with the outcome or educational objective that one is striving for. Instruction involved in toilet training may be quite different than instruction involved in helping a child learn to experience disappointment without crying. Similarly, helping children make discriminations involves a different set of instructional operations than does helping them master concepts or principles. The point is, simply, that instruction takes its focus, content, and often its form, from the nature of the outcome that is being pursued. For this reason, decision regarding the design of instructional experience must be tied to learner outcomes.

In the design of formal instructional systems, as outlined by Hamreus, the desired outcome must be specified explicitly and defined in operational or behavioral terms. In carrying on less formal instruction the outcome desired may or may not be made explicit but it must be clearly in mind, for here, as in formal instructional systems, both the content and operations of instruction are dependent upon it. Granting the validity of this point of view, two critical questions arise: 1) "What are the most relevant classes of learner outcomes to pursue?" and 2) "How does one put these forth so as to maximize the instructional decisions intended to bring them about?" The first question of course is not new to education, but the second is, and it is on the second question that the present section of the paper focuses.

Most simply stated the aim of this section of the paper is to develop a taxonomy of learner outcomes that has utility in the design of instructional experiences. Put more exactly, the aim of this section of the paper is to develop a first approximation to a taxonomic framework which 1) is exhaustive of all possible learner outcomes, yet is understandable and manageable, 2) provides order to the myriad of taxonomies of learner outcomes that currently exist, and 3) increases the probability that the user of the taxonomy will make sound decisions in planning either formal or informal instructional experiences. *The basic assumption underlying the effort to develop such a taxonomy is that the instructional conditions needed to effectively bring about various kinds of learner outcomes will vary according to the classification of outcomes on the taxonomy, that is, that there is a systematic relationship between classes of instructional content, operations and learner outcomes.* This of course is highly probable since instruction has been able to be ordered with some degree of effectiveness and since patterns in instruction are recurrent. If it were not probable the task of the instructional designer would seem to be relatively hopeless, for each outcome to be developed would require the arrangement of an essentially different set of instructional experiences. The rationale underlying the effort is relatively straightforward: 1) such a taxonomy is needed, and 2) it's not currently available.

An Overview of Taxonomies of Learner Outcomes

As anyone who has given attention to the issue knows, the field does not lack in such taxonomies. Seemingly, every specialized group of professionals that have anything to do with children have developed a taxonomy or a series of taxonomies of learner outcomes, and by and large there is little overlap between them. At least six major sets of taxonomies can be identified: 1) those used by developmental psychologists, 2) those used by personality theorists, 3) those used by psychoanalytic or "ego" psychologists, 4) those used by educators, 5) those used by learning psychologists, and 6) those used by training psychologists. Because of limited reading time in the institute these various taxonomies are reviewed in Supplement 1. While the framework that is prepared as a synthesis of these views may be understood without reading the review section it is strongly recommended that institute participants read the review if at all possible because it sets the proposed framework in a perspective that is otherwise impossible to give. Included in the review are such well known taxonomies as those of Kearney (1953), Bloom (1956), Guilford (1959), Taba (1964), Krathwohl et al. (1964) and Gagne (1965).

Adaptive Systems and the Components of Cognition.
A Proposed Two-Level Taxonomy of Learner Outcomes

It is clear from a review of the various positions that have been taken with respect to learner outcomes that they can be and have been conceptualized in a wide variety of ways. It is also clear that each of the taxonomies has a legitimate base: by and large they simply deal with different levels of outcome, e.g., outcomes which crosscut the broad spectrum of human development vs. those which crosscut only that which is learned, or with different classes of outcome within the same level, e.g., those which focus upon content objectives in cognition vs. process objectives.

On the assumption that any functional taxonomy of learner outcomes must reflect multiple levels and multiple classes within levels an integrated, two-level taxonomy of learner outcomes is proposed as a synthesis of that which has been reviewed. The first level of the taxonomy deals with the major categories of human development and or functioning, and has as its function the sorting of outcomes into those which are "learned," those which are "shaped," and those which represent a "residue" of the total spectrum of experience. The second level of the taxonomy is designed to deal in detail with each of these three general classes of outcomes. Because of space and time limitations, however, and because the ins'i'''e is directed primarily to educators, detailed attention will be directed only to the cognitive or "learned" outcomes in the present paper. In combination, however, and if developed in detail, the two levels of the taxonomy have been designed to provide for an integration of most of the classes of learner outcomes that have traditionally been of concern to educators and psychologists.

Taxonomy 1: Adaptive systems. An emerging theory of human development (Schalock, 1968) has been used as a basis for ordering developmental outcomes into the systems that appear in the taxonomy. Briefly stated the theory holds that three broad classes of adaptive systems have arisen over the course of the evolutionary history of man, corresponding roughly to 1) the need for internal regulatory mechanisms that lead to the survival and growth of the organism (the regulatory or vital domain), 2) the need for interpersonal-relational systems which lead to the perpetuation and viable social ordering of the species (the interpersonal or generative domain), and 3) the need for competencies which permit the adaptation of the organism to the demands of the external environment (the cognitive or competence domain). Within each of these three major domains the theory holds that three adaptive systems operate, each corresponding roughly to the major sets of adaptive demands that appeared with each benchmark of biological evolution. Thus, as biological evolution progressed, new classes of regulatory or vital mechanisms, new classes of interpersonal or generative relationships and new classes of competencies or commitments were needed in order to meet the demands of increasingly complex organisms in increasingly complex environments. Ultimately, through the constant process of adaptation, viable adaptive subsystems finally became part of the genetic inheritance of man. The theory holds that as a consequence each human being, through the interaction of experience and genetic programming, develops and maintains the nine adaptive systems outlined above. It holds further that developmental tasks, learner outcomes and, in fact, all of human experience gets ordered in relation to these systems. The three major domains of human development, their adaptive systems, and the evolutionary epochs in which the systems evolved, appear in Table I.

Several features of Table I require comment in light of existing taxonomies. First there is no set of outcomes labeled "affective." Instead, the taxonomy explicitly defines emotional outcomes and attitudinal outcomes, and thus separates two of the major concepts that have come to be entwined in the notion of affective outcomes. Conceptually, in the present scheme, attitudinal outcomes substitute for affective outcomes (in the Krathwohlian sense) and thus are learned, whereas emotional

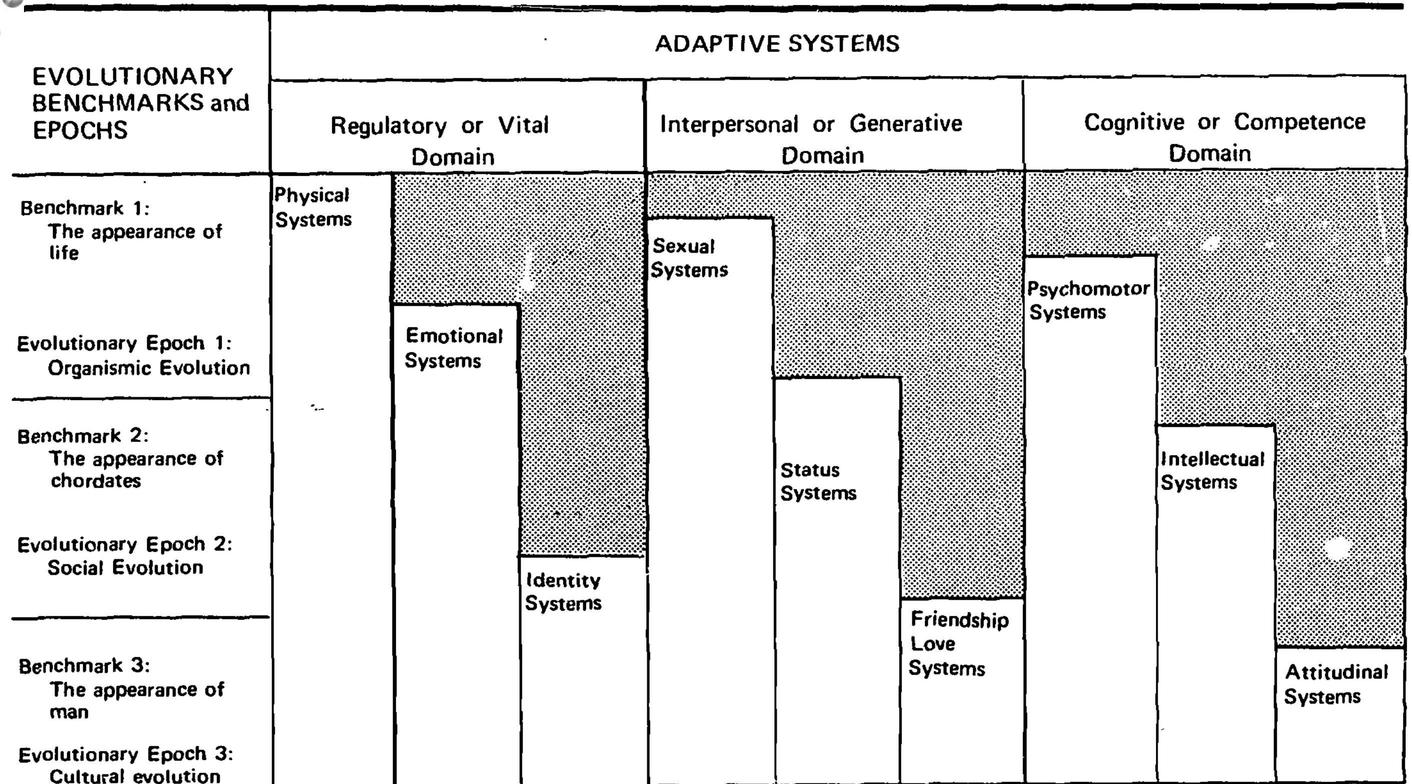


Table 1. The adaptive systems of man, ordered according to the nature of the adaptation required and the evolutionary period during which they appeared.

outcomes are more generalized and relatively unaffected by learning (except, perhaps, in the Pavlovian sense).

Second, the term cognition has been used as the generic term for all classes of learning or competence outcomes, with the term intellectual outcomes substituting for it in the usual psychomotor-cognitive-affective triumvirate.

Third, it is assumed that only cognitive or competence outcomes are "learned" outcomes; outcomes in the vital domain are viewed as accruing as a "residue" from all that happens to an organism in the course of its existence, and outcomes in the interpersonal domain are seen as being "shaped" rather than learned. While such terminological gambits may have the appearance of playing word games they are not intended as such. In the present view the influence process in the vital and generative domains is conceived to be something other than teaching, and the processes by which vital and generative outcomes evolve are viewed as something other than learning. To be sure, *one may learn about* vital and generative outcomes, but one doesn't *develop* outcomes in these domains through learning. What the specific developmental and influence processes are within these areas is yet to be determined, but there is a fair probability that they will be something other than that which we now characterize as learning. The present effort, including the rather crude terminology, represents a first effort to give credence to the probability of their existence.

As implied above the developmental theory holds that for each domain and adaptive system there is a corresponding class of influence behaviors which is responsible for the development and maintenance of that system. This proposition stems from the assumption that while all adaptive behavior patterns have a genetic base, all require for their development and maintenance a continuous interchange with relevant dimensions of the external environment, e.g., relevant classes of *influence behavior*. Three broad classes of influence behavior, corresponding to the three broad domains of human development, have been identified: caretaking, socializing, and teaching. Generally speaking these are defined as follows:

Caretaking: Those behaviors which lead to the development and maintenance of the *regulatory mechanisms* involved in the physical, emotional and self-definitional needs of another;

Socializing: Those behaviors which lead to the development and maintenance of the *interpersonal orientations* involved in the sexual, status and friendship-love relationships of another;

Teaching: Those behaviors which lead to the development and maintenance of the *competencies and or commitments* involved in the psychomotor, intellective and attitudinal orientations of another.

Technically, as used within the present framework, influence behavior is defined as behavior which one person directs to another (or group of others) which has as its intent the modification or maintenance of the behavior of another.

As indicated above, it is also proposed that classes of influence behavior exist which correspond to or link with each of the adaptive systems within the three domains of development. At the moment only the subsystems within the teaching domain have been identified, but it is assumed that relatively independent patterns of influence behavior ultimately will be identified for each adaptive system. The three classes of influence behavior within the teaching domain have been labeled, respectively, training, instruction, and enculturation. Operationally, within the present context, *training* refers to teaching in the psychomotor area, *instruction* to teaching in the intellectual area and *enculturation* to teaching in the attitudinal area. The various classes of influence behavior and the adaptive systems which they parallel are listed in Table 2. Taken together, the taxonomy of developmental outcomes (adaptive systems) and their respective classes of influence behavior provide a language and a system for ordering developmental concepts which should have considerable utility for education.

Taxonomy 2: Components of cognition. Using the terminology of existing taxonomies, an integrative taxonomy would have to include classifications that would incorporate the following major headings:

FROM THE EDUCATIONAL PSYCHOLOGISTS AND CURRICULUM SPECIALISTS

- Psychomotor Outcomes
- Cognitive Outcomes
  - Content (curriculum specialists)
  - Process (educational psychologists)
- Affective Outcomes

FROM THE LEARNING AND/OR TRAINING PSYCHOLOGISTS

- Signal Learning
- Stimulus Response Learning
- Chaining
- Verbal Association
- Multiple-Discrimination Learning
- Concept Learning
- Principle Learning
- Problem Solving

ADAPTIVE SYSTEM	CORRESPONDING CLASS OF INFLUENCE BEHAVIOR
Regulatory or Vital System	Caretaking Behavior
The Physical System	—
The Emotional System	— (to be identified)
The Identity System	—
Interpersonal or Generative Systems	Socializing Behavior
The Sexual System	—
The Status System	— (to be identified)
The Friendship-Love System	—
Cognitive or Competence System	Teaching Behavior
The Psychomotor System	— Training
The Intellective System	— Instruction
The Attitudinal System	— Enculturation

Table 2. The adaptive systems of man and the classes of influence behavior responsible for their development and maintenance.

As indicated above substitution of the terms Intellectual and Attitudinal for Cognitive and Affective in the first level taxonomy has already altered the list slightly. The critical problem remains, however, and that is the development of a framework that brings the concepts of cognitive content and process into juxtaposition with the concepts of signal learning, stimulus-response learning, concept learning, etc., and all three of these into a meaningful relationship with the three major classes of cognitive outcomes, i.e., Psychomotor, Intellective and Attitudinal. The taxonomy outlined below is a first attempt to make fit of this kind.

In deriving the taxonomy, the analysis of cognitive development and functioning was approached from the point of view applied in the analysis of the physical domain of man, namely, that there is a cognitive structure, that cognitive structure has certain functions, and that it consists of a given content. This represents the classic approach to analysis in the biological sciences and it was anticipated that it would have utility in the analysis of the cognitive domain.

The taxonomy that evolved from the analysis involves a three dimensional model of outcomes. The three components of the model are labeled Structure, Function and Content, and correspond, respectively, to the outcomes purposed by the learning psychologists, the educational psychologists and the curriculum or discipline specialists. Operationally, it is assumed that the Structure and Function components of the model, i.e., associations, discriminations, concepts, etc.(elements of cognitive structure) and recognition, understanding, and application (levels of cognitive, functioning) are applicable across the three major classes of cognitive outcomes, while the Content of Cognition varies not only by general class of outcome but by subclasses of outcome within the psychomotor, intellectual and attitudinal realms. This position is in line with the general conclusions of Melton (1964), and is illustrated schematically in Figure 5.

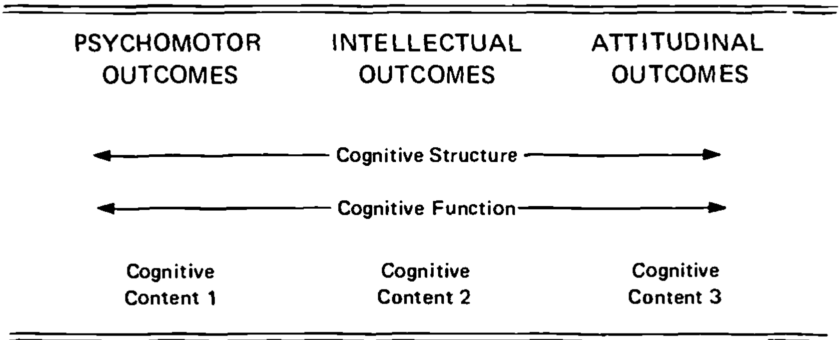


Figure 5. A schematic representation of the relationship between cognitive structure, function and content, and the three major classes of cognitive outcomes.

Cognitive Structure. When thinking of structure, Suzanne Langer's notion is relevant:

> "The structure of a thing is the way it is put together. Anything that has structure must have parts, properties, or aspects which somehow are related to each other." (As cited by James Moffett in the *Harvard Educational Review*, Summer Issue, 1966).

In this sense cognitive structure is seen as paralleling that of physical structure in that it is composed of a number of distinct elements organized into increasingly complex units. In the physical domain the units of organization include, from the simplest to the most complex: atoms, molecules, cells, tissues, organs, and systems. It is proposed here that the cognitive domain is organized on much the same pattern and includes the following, ordered again from the simplest to the most complex: discriminations, associations, concepts, principles, plans and systems. These units correspond in level of complexity to those identified within the physical domain, and are derived from a combination of the concepts current in the literature on learning and those central to the conceptual framework outlined in Table 1. Figure 6 contains a hierarchically ordered listing of the units of structure within the phy.: :al domain and the proposed units of structure within the cognitive domain.

PHYSICAL STRUCTURE	COGNITIVE STRUCTURE
Atoms	Discriminations
Molecules	Associations
Cells	Concepts
Tissues	Principles
Organs	Plans
Systems	Systems

Figure 6. Structural elements within the physical and cognitive domains in man, ordered according to complexity of organization.

Several observations may be made about this testing. First, the listing is hierarchical in nature. When considering the physical structure of the organism one has to specify the level of organization at which one is focusing, for the units of physical structure are organized hierarchically. Thus, when considering physical structure, one has to specify the level at which he is focusing: the atomic level, the molecular level, the cellular level, the tissue level, the organ level, or the system level, for example, the respiratory system, the circulatory system, or the digestive system. It is proposed heie that the cognitive structure of the organism is similarly organized, progressing from discriminations to associations, concepts, principles, plans and systems. Space is not available for the review of literature which supports such a classification scheme, but for the interested reader the following references are suggested: Gagne (1964, 1965) for a general treatment of the issue and a taxonomy similar in kind; Tolson (1932) for a discussion of discrimination as the basic element within cognitive structure; Klausmeier and Harris (1966) for an analysis of concept learning; and Fitts (1964) and Miller, Gallanter and Pribram (1960) for a discussion of the concept of plans.

Second, the last three elements within the cognitive listing involve processes of organization and transformation that transcend that which is .earned explicitly. While the crucial evidence is not yet in with respect to the role of organization and or transformation processes in cognitive development and functioning, there is growing commitment to their centrality. This is reflected in Osgood's "behavioristic" analysis of perception and language (1964), in a recent symposium on coding and conceptual processing in verbal learning (1964), and in a paper on verbal learning by Tolving (1964):

> At the empirical level, SO (subjective organization) refers to the subject's tendency to recall certain items in close temporal contiguity to one another. At the conceptual level, this tendency can be thought to represent the formation and existence of higher-order memory units. It is as if the list items. . . are rearranged in storage in the course of . . . practice. Such rearrangement manifests itself and can be described in a variety of ways–development of associations of clustering in terms of conceptual (Bousfield, 1953; Cohen, 1963), associative (Jendkins and Russel, 1952) or synonymic (Cofer, 1959) categories; chunking, unitization, or recoding as envisaged by Miller (1956a, 1956b); construction of a plan, or creation of a hierarchical structure (Miller, Galanter and Pribram, 1960); employment of various 'mnemonic aids' as described, for instance, by Balaban (1910) and Bugelski (1962); ordering of items in recall according to a previously learned code such as the alphabet (Tulving, 1962b); and probably many others. Subjective organization is just a general name for all of these processes (p. 234).

In passing it may be noted that the operation of organizational or transformation processes is well known within the physical realm; the *input* of oxygen, nutrients, etc. to the organism has no direct bearing in and of itself on tissue formation, organ formation, or system organization. Like the last three elements within the cognitive structure, tissues, organs and systems derive from organizational or transformation process which transcend that which comes into the organism initially. Whatever the specific processes may be that accomplish transformations within the physical and cognitive domains, it is highly probable that they are under the control of genetic programming.

The third, and perhaps the most critical observation to be made with respect to the two listings centers on the concept of systems. When looking at physical structure, physiologists long have made use of the concept of systems, and have been able to establish the outline of various adaptive systems by tracing the organizational relationships between organs in carrying out a given adaptive function. Thus, in physiological terms, systems have been identified to accomplish the function of respiration, elimination, nutrient transportation, etc. In this sense, systems within the physical domain may be considered as internal adaptive systems necessary to the survival and well-being of the organism.

Within the context of the developmental theory basic to the present framework (Schalock, 1968) it is proposed that a comparable organization of structure exists within the cognitive domain, permitting the organism to adapt effectively to the external demands of the environment. In contrast to the *internal adaptive systems* of the physical domain these have been labeled *external adaptive systems*, and while the elements that need to be processed within the physical realm are those of food, waste products, foreign elements, disease carrying agents, etc., the elements which must be processed in the cognitive domain are those objects, events and processes in the external world with which the organism must continually interchange.

As reviewed earlier, the theory holds that external adaptive systems are genetically based, organizing action patterns which guarantee that an organism will attend to the fundamental adaptive operations necessary to its survival and the survival of the species. Three external adaptive systems have been proposed: the vital system, which takes as its focus the maintenance of life and personal integrity; the generative system, which takes as its focus companionship, affection and sexuality; and the competence system, which takes as its focus knowledge, awareness, operative within all human beings at all age levels, and as providing the primary organizational framework for cognition and behavior.

Cognitive Function. Like structure, function is a concept that is of central significance throughout the biological sciences. Generally speaking, it refers to the natural or characteristic action of an organ or system of organs in a plant or animal. The term carries the same meaning in the present paper, referring to the natural action or function of cognition in the overall functioning of the organism.

As conceived in the present framework there are three hierarchically arranged functions of cognition: comprehension, understanding and application. Operationally, comprehension is defined as the ability to recognize, differentiate, translate, etc.; understanding as the ability to extrapolate, draw analogies, make inferences, etc.; and application as the ability to perform given operations or find solutions to given problems under simulated or real life conditions. Central to the framework is the assumption that before one can "understand" one has to comprehend, and that before one can make application one must "understand." The relationship between the proposed taxonomy of cognitive functions and Bloom's and Taba's taxonomies of cognitive processes is illustrated in Figure 7. By and large, there is little relationship between these taxonomies and that presented by Guilford (see Fig. 3).

It will be seen in Figure 7 that there is only moderate agreement between the three classification schemes: the last three categories in Bloom's taxonomy and the first two categories in Taba's are of a different order than those in the proposed taxonomy. At one level it

THE PROPOSED COGNITIVE FUNCTIONS TAXONOMY	BLOOM'S COGNITIVE PROCESSES TAXONOMY	TABA'S COGNITIVE PROCESSES TAXONOMY
Comprehension	Comprehension	Grouping & Classification
Understanding	Application	Interpretation and Drawing of Inferences
Application	Analysis	Application
	Synthesis	
	Evaluation	

Figure 7. The relationship between categories in the proposed taxonomy of cognitive functions, Bloom's taxonomy of cognitive processes, and Taba's taxonomy of cognitive processes.

probably would be possible to interpret Bloom's Analysis, Synthesis and Evaluation categories and Taba's Grouping and Interpretation Categories as special instances of the application category in the proposed taxonomy, but I think this would be misinterpreting these authors' intention of the categories. In the present scheme these categories are seen as legitimate classes of "process" outcomes (see below) and are treated as such.

Conceptually, the functional outcomes of cognition are as pervasive and fundamental to cognitive operation as are structural outcomes: the nature of the environment in which an organism operates must be comprehended, understood and acted upon. Since these functions are critical to the survival and adaption of the organism, it is assumed, as it was with structural outcomes, that they have their basis in the genetic programming of the organism.

In combination, *the taxonomy of structural outcomes and the taxonomy of functional outcomes constitute the central classification of cognitive outcomes toward which instruction needs to be directed.* The relationship between these two sets of outcomes is illustrated schematically in Figure 8. As indicated earlier, however, cognition structure and function do not exist in a vacuum; they are always tied to content. As a consequence, *the direction of instruction toward structural and functional outcomes must always be done within the context of content.* This in no way lessens the significance of structural and functional outcomes as targets of instruction, but it does say that in and of themselves they are insufficient targets.

ELEMENTS OF COGNITIVE STRUCTURE

LEVELS OF COGNITIVE FUNCTIONING	Discriminations	Associations	Concepts	Principles	Plans
Comprehension					
Understanding					
Application					

Figure 8. The schematic relationship between cognitive structure and cognitive function.

As ordered in Figure 8 it can be seen that levels of cognitive functioning in a sense represent operational definitions of the levels of mastery which one has over the use of the various elements within his cognitive structure. This relationship can be used to good advantage in assessing the outcomes of instruction, for one can use the various levels of cognitive functioning as a guide to the development of criterion instruments.

Cognitive Content. As indicated previously, the content of cognition represents the "stuff" into which cognitive structures are formed and with which cognitive functions deal. It is generally agreed that it consists of both *substantive* outcomes e.g., the laws of physics, the sounds of Beethoven, the vision of birds in flight, the feel of tennis racquet and ball, the smell of meadows, and *process* outcomes, e.g., observation, analysis, synthesis, hypothesis generation, evaluation. *In the present scheme an integration of substantive and process outcomes provides the content of psychomotor, intellectual and attitudinal adaptive systems. Conceptually, however, content outcomes occur only after sensory experience has been translated into cognitive structure and has thereby become available to cognitive functioning.*

1. *Substantive Outcomes.* Unfortunately, the development of a taxonomy of substantive outcomes is beyond the scope of the present effort. This is the case for two reasons: 1) A functional classification of all possible substantive outcomes across all topic areas within the

psychomotor, intellectual and attitudinal domains is beyond the writer's comprehension; and 2) even if such a classification were possible, I'm not sure what one would do with it, except possibly to use it as a guide in curriculum development, since it would be unbelievably massive and subject to continuous change. If it someday becomes possible to describe the "structure" of disciplines (Bruner, 1967) and perhaps similarly the "structure" of attitudes and psychomotor skills, a taxonomy of substantive outcomes might become relevant, but for the present it is doubtful that a great deal of advantage could be gained from such an effort.

After having said all this the spirit of the paper still dictates that at least some of the parameters of such a taxonomy be generated. Toward this end a three dimensional model is offered. The major parameters of the model are: 1) Focus, i.e., the adaptive system and the topic area within the system that is under consideration; 2) Content, i.e., the objects, events, or processes that constitute a particular focus; and 3) Form, i.e., the structural properties of the objects, events or processes that are being considered. As used here, the concept of Form derives directly from Guilford's model of cognitive processes. The parameters of the model are presented schematically in Figure 9.

2. *Process Outcomes.* As with substantive outcomes the development of a functional taxonomy of process outcomes is beyond the scope of the present effort. In contrast to substantive outcomes, however, the development of such a taxonomy is critically needed and would have far

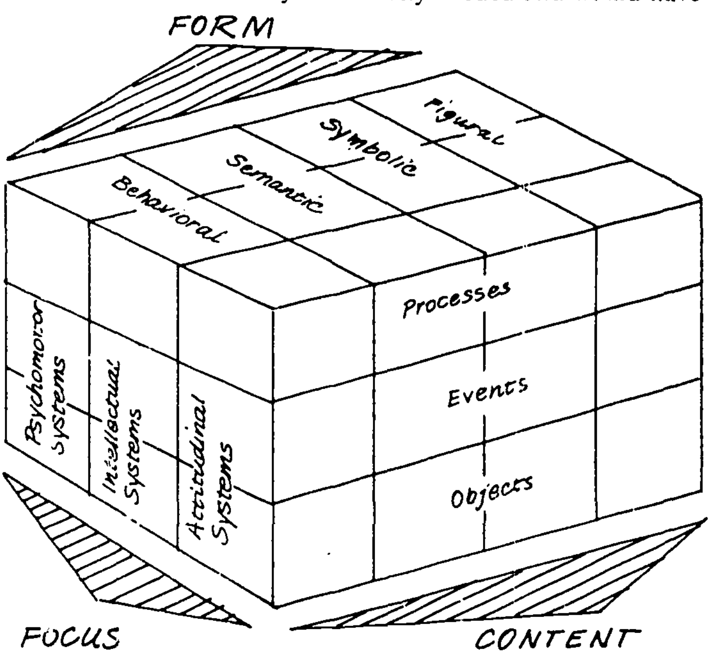


Figure 9. A three dimensional model of substantive outcomes.

reaching value. Process outcomes constitute the "cogniti ~ tools" or skills with which an individual app oaches his world, and the number and kind of such tools determines to have a large extent how successfuly he adapts to it. These are competencies central to learning, achievement, the advancement of knowledge, the development of athletic ability and the modification of attitudes, and as such should be of central concern to educators.

At the moment an exhaustive taxonomy of process outcomes does not exist, although some of the categories within Bloom's and Taba's taxonomies can appropriately be considered as process outcomes. These include, specifically, the categories of Analysis, Synthesis and Evaluation from Bloom and the categories of Grouping and Interpretation from Taba. Another relatively exhaustive listing of process outcomes is found in the AAAS *Science As a Process* materials. Starting with Observing, the list includes, in an "hierarchical" order, Classifying, Measuring, Communicating, Inferring, and Predicting. A second level of AAAS outcomes include Formulating Hypotheses, Making Operational Definitions, Controlling and ManData. These processes of course have been designed only for the science area. and point up one of the more critical issues facing the developer of a taxonomy of process outcomes, namely, whether such outcomes are generalizable or whether specific sets of process skills are needed in different adaptive systems, or for different foci within systems. The critical point, however, is that at this time there is no exhaustive listing of process outcomes available and such a listing is badly needed.

Assuming that system specific process outcomes exist, that is processes specific to the development of psychomotor skills, intellectual abilities and attitudinal orientations, a taxonomy of such outcomes would take the form form of a three dimensional model much like that outlined in Figure 9. Such a model appears as Figure 10.

In considering the development of process outcomes it needs to be realized that, as in the case of substantive outcomes, *process outcomes can be realized only after relevant experiences have been translated into cognitive structure and thereby made available to cognitive functioning.*

A Summary of the Relationship Between Adaptive Systems and Structural, Functional and Content Outcomes.

Figure 11 contains a schematic illustration of the relationship between these various classes of outcomes. Interpreting the figure, the transformation of sensory experience into structural units (elements of cognitive structure) over which there is some degree of mastery or control (cognitive functioning), the translation of these into substantive and process outcomes, and the integration of these into psychomotor,

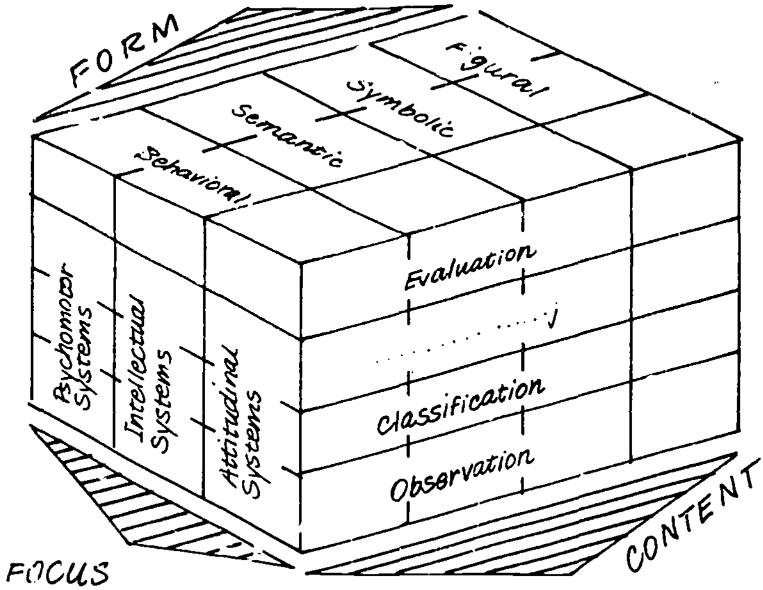


Figure 10. A three dimensional model of process outcomes.

intellective and attitudinal systems that are adaptive in their service to the organism constitutes the process of learning. It also provides a hierarchy of learner outcomes which serve as a guide to the design of instructional conditions. At the most basic level and in all cases instructional conditions must be designed to influence discriminations, associations, concepts, principles and plans, for these are the outcomes from which all other classes of outcomes derive, but these are not sufficient guides in and of themselves. In addition, the instructional designer must also take into account the level of mastery desired over the structural outcome, whether it is a substantive or process outcome and whether it is a psychomotor, intellective or attitudinal in nature *for the design of effective instructional experiences will vary accordingly*. On the basis of this kind of thinking, the taxonomy at one and the same time 1) forces the reduction of all specified outcomes, whatever their level of generality, to the structural and functional level and 2) forces the expansion of the outcome to the level of adaptive systems and the domain of human functioning. Operationally this means that a hierarchical analysis must be applied to any and all learner outcomes pursued, and that any level of outcome, including those traditionally sought by the personality or ego psychologists, are appropriate *as a place to begin*. More will be said about the concept of hierarchical analysis in a later section of the paper.

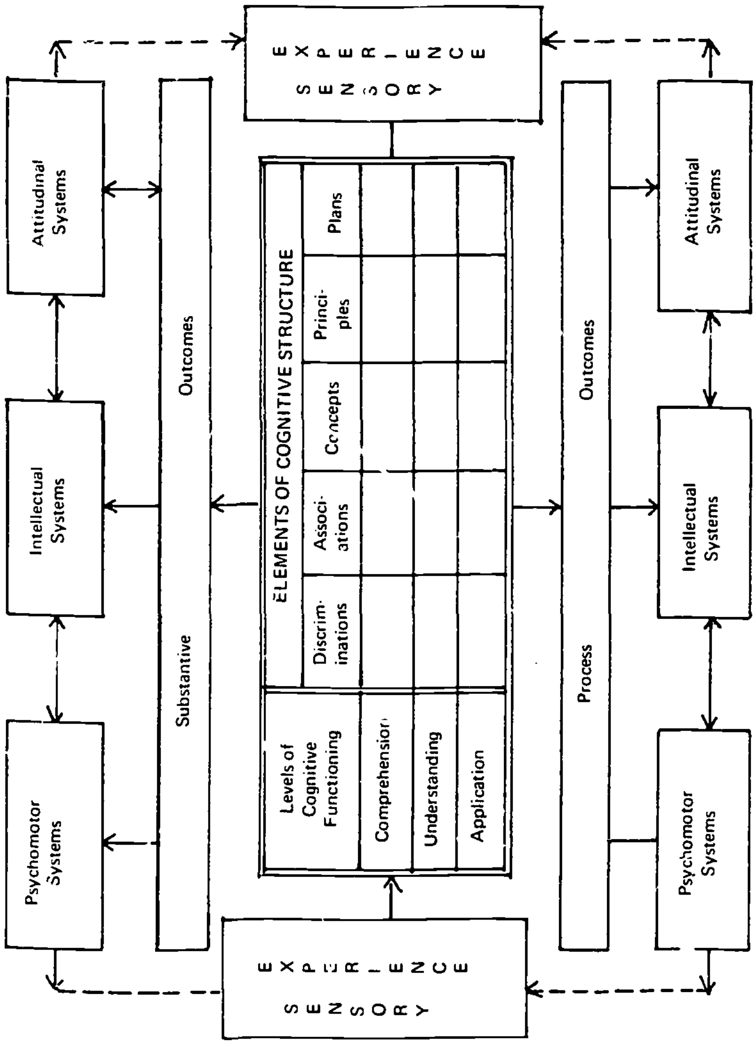


Figure 11. The schematic relationship between adaptive systems and between structural, functional, and content outcomes.

Implications for Instructional Design

As indicated previously, a basic assumption underlying a systematic approach to instruction is that there must be a fit between the conditions of instruction, the learning process, the nature of the learning outcome to be developed, learner characteristics, and setting characteristics. The proposed taxonomy is intended as a first approximation to a system for ordering the nature of learning outcomes. If used seriously, the taxonomy would lead to an ordered series of classifications which would, when taken together, provide a detailed description of the nature of the learning outcome that is being pursued. Ultimately, it is envisaged that specific sets of instructional conditions will be identified as appropriate to the development of specific classes of outcomes. If and when this information becomes available, the task of the instructional technologist will be greatly simplified: as soon as he knows the class of outcome desired he will be able to select the set of instructional conditions that will bring the outcome about within a known degree of reliability for a given set of learners under a given set of situational conditions.

Returning now to the specification of target outcomes for purposes of guiding either informal instructional moves in the development of formal instructional systems, three steps are seen as being necessary in such specification: 1) identifying what the outcome in fact is to be, 2) describing the outcome in behavioral terms, that is, describing it in terms of its focus, form and content (see Figure 9 and 10), and 3) classifying the outcome in terms of the taxonomy of outcomes, as this appears in Figure 11.

Identifying Target Outcomes. This requires that in some way or another that which one wishes to accomplish or bring about as a consequence of an educational experience be known and can be explicated. These may be given by an authority, arrived at independently or derived from an extensive task analysis, and they may take any degree of specificity or generality, for example, they may range from spelling a word correctly to wiring a computer board without error to developing a feeling of confidence in a given situation. The critical element in this step of the process is that by whatever means the outcome desired is identifiable.

Describing Target Outcomes Behaviorally. While a number of formulae have been presented for the drafting of educational objectives in behavioral terms, cf. Mager (1962) and Paulson (1967), simple guidelines have been presented above as points of reference in the description of objectives. The procedure suggested here requires that the objective needs to be described in terms of its focus, form and content, but that is all. *It does not require that the criteria that will be accepted as evidence of the objective having been achieved be included in the initial description of the target outcome.* This position, namely, that one needs to keep separate conceptually and operationally the description or the desired objective and the development of the criterion measure that is to be used as evidence of the realization of the objective, differs considerably from the position taken by Paulson and Mager. The rationale underlying the present view is that by defining an objective in terms of measures to be used in assessing its realization one severely limits the scope of thinking or imaginativeness that can be introduced into the specification of learning outcomes. It is also based on the assumption that at best a measure reflects only selected or representative parameters of the phenomenon that is being measured; and in this sense constitutes no more and no less than a set of indicators that one is willing to accept as evidence of the phenomenon in question. Given this point of view the defining of behavioral objectives in terms of the measures to be used in assessing them is seen as an unnecessary set of constraints under which to operate.

Classifying Target Outcomes in Terms of the Proposed Taxonomy of Learner Outcomes. As soon as one knows clearly what the target outcome is to be, and has defined it behaviorally, the third step in the specification process is to classify the outcome in terms of the proposed taxonomy of outcomes. Operationally this means that one needs to specify a) the domain of human functioning that is represented by the outcome (Vital, Generative, Cognitive), b) if it falls within the cognitive domain then specify the adaptive system within which it falls (Psychomotor, Intellectual, Attitudinal), c) specify the class of outcome it represents (substantive or process), d) specify the element of cognitive structure that it represents (discrimination, association, concept, principle, plan), and finally, e) specify the level of mastery desired over the outcome, that is, mastery at the level of comprehension, understanding or application. *The basic assumption underlying the specification of outcomes in terms of proposed taxonomy is that the instructional conditions needed to effectively bring about various kinds of outcomes will vary according to the classification of outcomes on the taxonomy.* If this is true, the implications for the instructional designer are clear: not only must he specify and describe behaviorally the nature of the target outcome but he must also be aware of and design into his instructional experience that which is known of the relationship between the conditions of instruction and the realization of given classes of outcomes. This is the focus of the third section of the paper.

Issue 4: Is it reasonable to assume that a functional taxonomy of learning outcomes can be established?

Issue 5: Assuming a positive answer to Issue 4, does the proposed taxonomy meet the criteria of (a) incorporating that which is known about human development generally and cognitive development specifically; (b) using a minimal number of concepts with maximal effectiveness; (c) providing clarity to an issue or area; and (d) utility in instructional systems design?

Issue 6: Are the assumptions underlying the proposed taxonomy of adaptive systems viable?

Issue 7: Are the concepts of the cognitive structure, function and content within the proposed taxonomy viable?

Learning Processes

As used in the present paper the term learning process refers to the internal mechanisms for or processes by which the elements of cognitive structure (discriminations, associations, concepts, etc.) are formed and the levels of cognitive functioning (comprehension, understanding, application) are carried out. As such the term refers to the essence of learning itself. Thus conceived, learning processes link directly to instruction, for instructional practice must reflect that which is known about the process of learning if it is to be maximally effective in facilitating learning. Fundamentally the learning process involves issues of information selection, transmission, storage, transformation and retrieval, as well as issues of attention, perception and volition. In the broadest sense it involves the historical issue of what goes on between observable stimuli and observable responses. Put in the parlance of the day, the issue focuses upon what goes in the central nervous system or "the little black box." The elements involved of the learning process are shown schematically in Figure 12.

The aim of this section of the paper is to bring into as clear a relief as possible that which is known about process of learning and its implications for the design of instruction. Toward this end much the same organization will be followed as appeared in the previous section of the paper, namely, an overview of positions held with respect to learning processes; the proposal of an integrative model of learning processes that incorporates both that which is known about process plus the concepts of cognitive structure and function developed in the preceding section of the paper, and a listing of the implications of the model for instructional design. As background for this section of the paper, a synopsis of the positions held by some of the leading theorists representative of the two

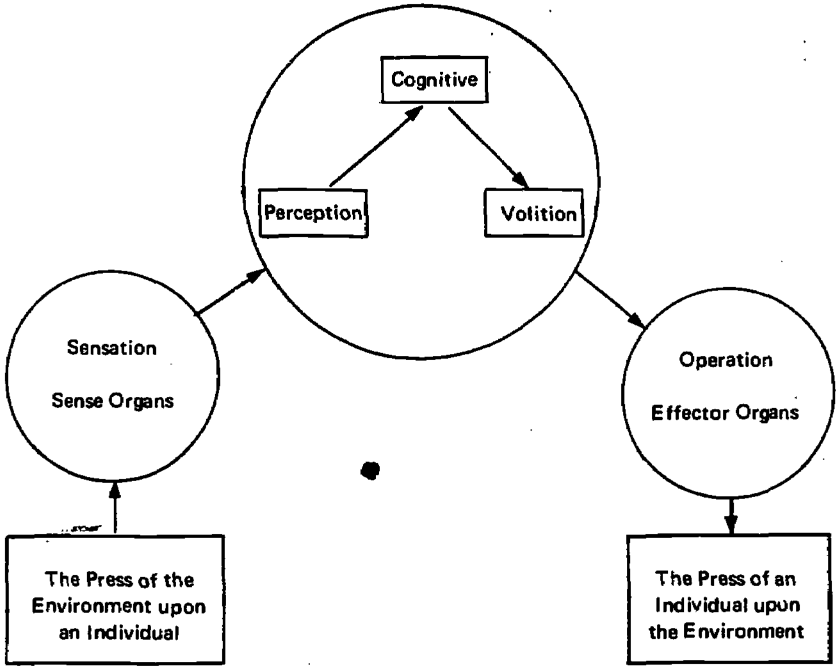


Figure 12. A schematic representation of the elements involved in the learning process.

major points of view in psychology toward the process of learning are provided. These appear as Supplement 2. An overview of the various points of view themselves appears as Supplement 3.

An Overview of Positions Held With Respect to Learning Processes

Most thinking about learning processes can be grouped around five models: 1) the traditional S-R model, 2) the traditional S-S model, 3) the "mediated" S-R model, 4) the cybernetic or information processing model, and 5) the neurophysiological model. The first three of these models represent points on a continuum of a debate that has raged amongst psychologists of learning for half a century over whether it is really necessary to refer to the processes that occur within the black box in order to explain behavior. The fourth and fifth models are relative newcomers to the scene but in all likelihood represent the models of greatest power in the future. The positions each of these models represents toward the process of learning is reviewed in Supplement 3. Since the model proposed in the present paper draws heavily upon the information processing and neurophysiological models, and since these models are generally less well known than the others, it is recommended that the reviews of these two models be read if at all possible during the institute if the reader is not already familiar with them.

Multiple Systems Operation: A Proposed Information Processing and Utilization Model As a Basis for Understanding the Nature of the Learning Process.

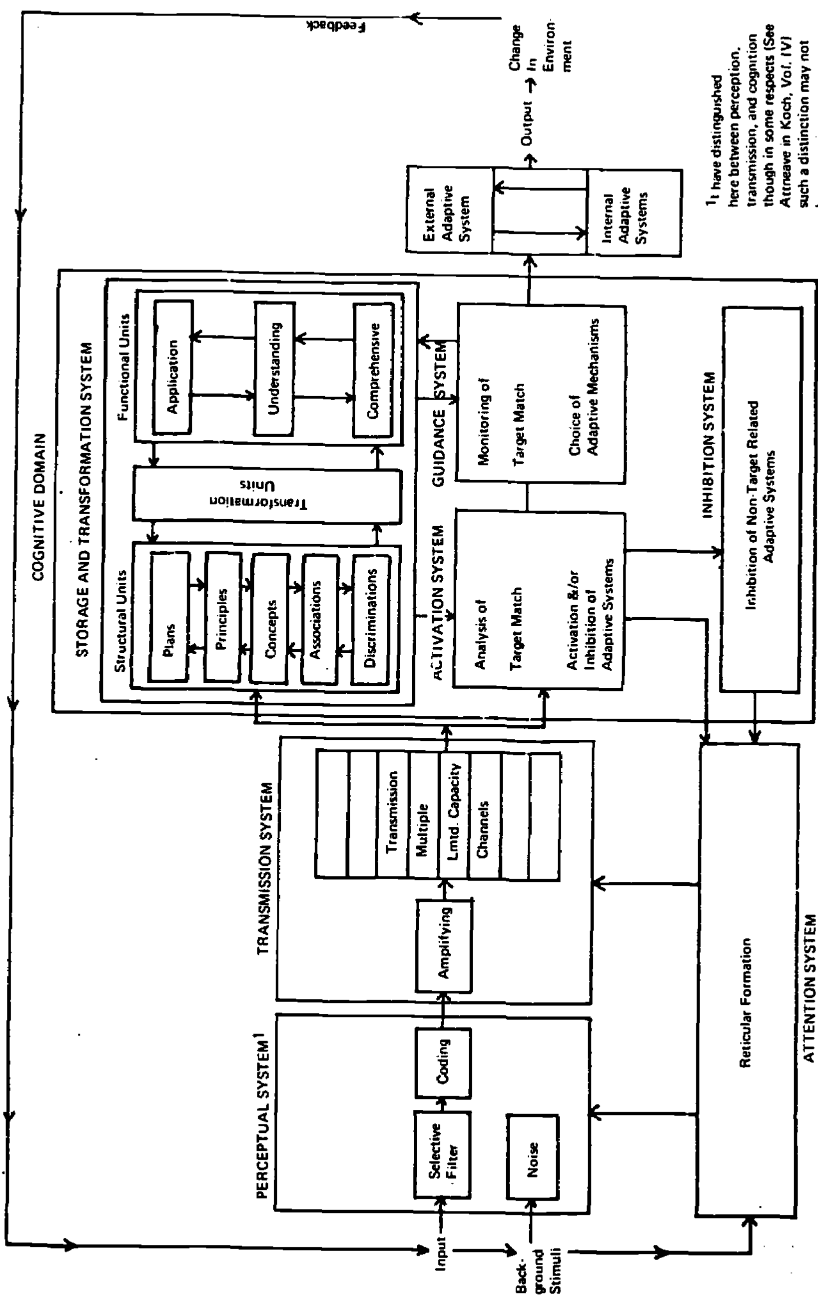
Ultimately the power of the science of man is related to the conception of man that it takes as its operating base. In my opinion the position which many psychologists have taken historically with respect to the nature of man has not been a particularly powerful one, at least not when compared to that which is possible by using the concepts of systems theory, cybernetics, or information theory. As a consequence the model of the learning process that is proposed is essentially a multiple systems, cybernetic, information processing model. In this respect it draws heavily from the work of Broadbent (1958), Travers (1964), Frank (1963), Von Bertalanffy (1950), Ashby (1960), Smith and Smith (1966), and others. It also draws upon information from neurophysiology that heretofore has not been incorporated into information processing models. While that which is proposed is still far from an empirically tested model, and describes cognitive operation only at the level of functional systems rather than physical or chemical structure, it is offered as a first approximation to the kind of systems design that ultimately, in my opinion, will dominate the area. The model is summarized schematically as Figure 18.

The model spells out the relationship between a series of relatively independent operational systems which, when linked in series, provide the functional whole which permits information processing and utilization to occur. Operationally, the proposed model consists of seven systems. These have been labeled, respectively, the perceptual system, the transmission system, the attention system, the storage and transformation system, the activation system, the guidance system, and the inhibition system. In all cases they coincide to empirically established functions which are known to exist within the functioning organism. The content of each of these systems will be described briefly and primary sources given for further reading for those who wish to pursue the area.

The perceptual system. As conceived here, the major elements of the perceptual system consist of receptor organs, a selective filtering device, and a coding mechanism. The evidence for the existence of these components is summarized in Broadbent (1958) and Travers (1964).

The transmission system. Again, there are two major elements conceived within the transmission system: a mechanism for amplifying the power of the signals that have been filtered and coded and a limited capacity multiple channel transmission system which generates its own power source for sending. Travers and Broadbent again provide excellent summaries of the empirical data leading to these derivations.

The attention system. The terms "energy mobilization," "activation," "arousal," "excitation," and the like have occurred recently with



[1] I have distinguished here between perception, transmission, and cognition though in some respects (See Attneave in Koch, Vol. IV) such a distinction may not be appropriate.

Figure 18. A Proposed Information Processing and Utilization Model

increasing frequency in the psychological and neurophysiological literature (Duffy, 1963) (Malmo, 1959) (Schlosberg, 1964). Also, a discovery of the arousal function of some of the lower brain centers, for example the reticular formation (Magoun, 1958), and recent work on sensory deprivation and stimulation (Fiske and Maddi, 1961), a renewed interest in sleep, and the continued interest in the relationship between activation and performance, has lead to an entire rethinking of the place of activation in cognitive functioning. In essence the concept of activation relates to the earlier concept of motivation and has to do with energy mobilization, cortical activiation, etc. which is necessary to the attending function of the organism.

The storage and transformation system. The concept of an information storage and transformation system is well established in the psychological literature, including the literature of the traditional S-R theorists, but the content of the system has not been specified with any degree of clarity. In the present model it is proposed that the elements of cognitive structure and the units of cognitive functioning outlined in the previous section of the paper, in conjunction with transformation units which operate in relation to both structure and function, comprise the contents of the storage and transformation system.

The activation system. The activation system is viewed as intimately tied to the attention system (see above) but instead of having as its primary focus perception and transmission, as does the attention system, the activation system locks more closely into the information utilization function of the model. It also locks into the guidance and inhibition systems (see below) system functions much like Miller, Gallanter, and Pribram's TOTE Unit, analyzing incoming information for its fit or match with the existing store of information of the organism and the plan of operation that is current. Support for such a system can be found in Miller, Gallanter and Pribram (1960), Broadbent (1958), and Diamond, et al (1963).

The guidance system. The guidance system is conceived as a companion system to the activation system, serving much the same function in the utilization of information. It also is seen as operating like a TOTE Unit, but instead of functioning to activate or inhibit adaptive systems it serves to guide the choice of adaptive mechanisms once an adaptive system is activated. Primary support for the inclusion of a guidance system in a model such as this rests with the work of Diamond, Dalvin, and Diamond (1963).

The inhibition system. One of the most serious oversights of the psychologist's view of cognitive functions and behavior is the role which the inhibition of competing or alternative action patterns has for the performance of adaptive behavior. Diamond et al. reviews the extensive literature on the subject and on the basis of the evidence available it is clear that an information processing and utilization model must have within it a system to handle the inhibition function which is so necessary to effective performance.

Implications for Instructional Design

According to the proposed information processing and utilization model the learning process itself is not subject to manipulation by an instructor: all that is manipulable are the conditions which influence *what* the learner processes and to some extent *how* he processes it. The processing itself is internal and subject to the control of the fantastically complex mechanisms that Dame Nature has built into the human organism to handle the information processing and utilization task. Given this point of view, what implications can be drawn for the designer of instructional experiences? Two sets of implications can be identified: 1) those having to do with the variables to be manipulated in instruction, and 2) those having to do with the amount and kind of information contained in the variables being manipulated.

Variables to be manipulated in instruction. A close analysis of the information processing model suggests that three factors must be present if a child is to learn: 1) he must encounter and process information, 2) he must test whether he has control over the information, i.e., whether he can identify, abstract from or use the information by performing in relation to it, and 3) he must receive feedback as to the nature or extent of the control that he has. This is the case whether a child is engaged in self-guided or teacher-guided learning. A parallel set of "instructional operations" can be identified which seem to incorporate all possible instances of teaching behavior: 1) exposing the learner to information, 2) precipitating performance on the part of a learner so as to facilitate the transfomation or "processing" of the information taken in, and 3) providing feedback to the learner about his performance, either in the form of positive or negative evaluation (feedback, of course, is only a special class of information giving). Operationally, these categories desciptive of teaching behavior are defined as follows:

Exposure to Information: Any message which appears to have as its aim the *extension of knowledge, awareness, understanding, skill, etc., and which does not have qualities that would lead to its being classified as evaluation of performance*. Broadly speaking, messages of this kind take the form of either "talking" or "showing." Examples include telling a class or child what is planned for the day, reading a story, explaining how to work a math problem, illustrating through slides or a picture that which is being discussed, and demonstrating how a particular process works or movement takes place.

Precipitation of Performance: Any message which appears to have as its aim the *initiation of overt behavior on the part of a child or children*. Broadly speaking, messages of this kind take the form of either a demand or an inquiry. Examples include questions requiring an immediate answer, directions to ready materials for a lesson, excusing children for recess, and starting children to work in their workbooks, to read, or to take an examination.

Evaluation of Performance: Any message which appears to have as its aim the *conveyance of the rightness of wrongness, goodness or badness, appropriateness or inappropriateness of a behavioral act* (which may or may not have been precipitated by the teacher). Broadly speaking, messages of this kind take the form of praise or censorship; rewards or punishment. Examples include comments such as "Fine"; "Well done"; "That is correct"; "That is incorrect"; "Wrong"; "Shhh"; "Stop that"; "Sit down, Beth. You're bothering your neighbor "; and nonverbal actions such as a pat on the back (in praise), a finger to the lips to indicate quiet, a gold star, a finger pointed critically at a child who is creating a disturbance, a raised hand in the form of a threat.

In reading these definitions it is obvious of course that each of these three components of instruction may serve quite different functions within the instructional process. For example, exposure to information may serve to *structure* that which is to occur during the course of the period, *provide closure* to or a solution for a problem, etc. Similarly, performance may be precipitated in order to *monitor* that which a child knows, *guide* a subsequent response, or get a child to *apply* that which he already knows. So too with evaluation: it may serve either a *positive* or *negative* function; that is, it may serve to increase or decrease the probability of a similar behavior occurring in the future. The point is, however, that *in combination these three classes of instructional behavior define the range of variables to be manipulated by the instructional designer*.

Factors to be considered in designing the information flow in instruction. Several tentative conclusions or principles have come from the work of the information theorists that have particular relevance to the instructional designer as he plans the nature, content and flow of information within an instructional experience. These have been summarized well by Travers (1964), and while the points made should still be taken as tentative they are informative.

1) The nervous system facilitates the transmission of information ~~to~~ the higher centers that is of particular significance to the organism and, at the same time, tends to inhibit the transmission of less significant information.

2) Information transmission is best undertaken through one sensory modality at a time; evidence indicates that multiple sensory modality inputs are likely to be of value only when the rate of input information is very slow.

3) Since simultaneous inputs through more than one sensory channel produce inhibitory effects, caution should be exercised in introducing background material through one sensory channel while another is being used to transmit the main message.

Since only a small fraction of the information available at the receptor level is transmitted to the higher centers of the brain (in the case of vision the proportion of the information provided other receptors which become available for use is probably less than one part in a quarter of a million) learning situations should be designed in such a way that the most relative features of the message are those that are transmitted. The quest for realism and the emphasis on realism which has characterized the audiovisual field seems to have been the worship of a false god.

5) Since all information is coded by the nervous system, it is important that it be transmitted by easily coded dimensions.

6) Information is not satisfactorily stored when a passive learner is passively exposed to input, though some learning may occur under such circumstances. A continuous change in sensory inputs appears to be important for maintaining efficient transmission.

Issue 8: Do "physiologizing" and "information theorizing" hold any real value for psychologists and educators concerned with learning and instruction, or is it largely a game of words?

Issue 9: Even if "physiologizing", etc. ultimately were to have some value to educators, do you think that the *conditions of instruction* will ever directly reflect or tie to the kind of concepts outlined in the proposed model?

Issue 10: If a model such as the one proposed were ultimately to have value, is it too complex to be used by teachers and or administrators in the public schools?

Issue 11: If our information base becomes such that we *could* modify learning ability through drugs, do you think that the American public would permit their use on a large scale?

The Conditions of Learning

Ultimately, in either the pursuit of informal instruction or the design of formal instructional systems, the designer of instruction must provide or specify the conditions under which the desired outcome is to be acquired. *Operationally such conditions define the process of instruction or the conditions of learning.* In the classroom or in the home this constitutes a description or an illustration or a question or a reward or a book to read; in Dr. Hamreus' flow diagram of instructional systems development it constitutes Step 11. Under either circumstance it is the essence of the instructional process, for it defines and or creates the events with which the learner interacts and from which learning is intended to occur.

As stated repeatedly in the paper, to be maximally effective instructional events or the conditions of learning must be adjusted to the nature of the learning outcome being pursued, the nature of the learner, the nature of the setting in which the learning is to take place and the nature of the learning process. If carried to its logical conclusion this would require in the present section of the paper specification of the conditions or events that are maximally effective in bringing about each of the various classes of outcomes outlined in Figure 11 for various types of learners under various types of settings. Unfortunately, while this is the ultimate aim of a science of instruction, the knowledge available in the field at the present time does not permit such specification. Also, in view of the structure of the papers in the present institute, the content of Dr. Beaird's paper would have to be considered before such specification would have full meaning. As a consequence, the present section of the paper will be organized in much the same way that the two previous sections have been organized, namely, 1) an overview of traditional positions held with respect to the conditions of learning *without regard for specific classes of learner outcomes*, 2) the development of a conceptual framework which organizes what is known about the conditions of learning in relation to the content of the previous two sections of the paper, and 3) drawing implications from the framework for the design of instructional systems. Like other sections of the paper, the present section represents a basis for the development of a science of instruction as much as it does a compendium of information that the instructional technologist or instructional manager can use at this point in time.

An Overview of Positions Held With Respect to the Conditions of Learning

As just reiterated, the design of instruction must reflect the focus of a number of interacting forces in the learning situation. These are schematized in Figure 19. While such a scheme is useful in ordering the various classes of variables which must be taken into account in designing instructional experiences, it is not particularly useful when looking at the conditions of instruction *per se*. At this level it is necessary to move beyond such a framework and analyze the dimensions of the instructional process itself.

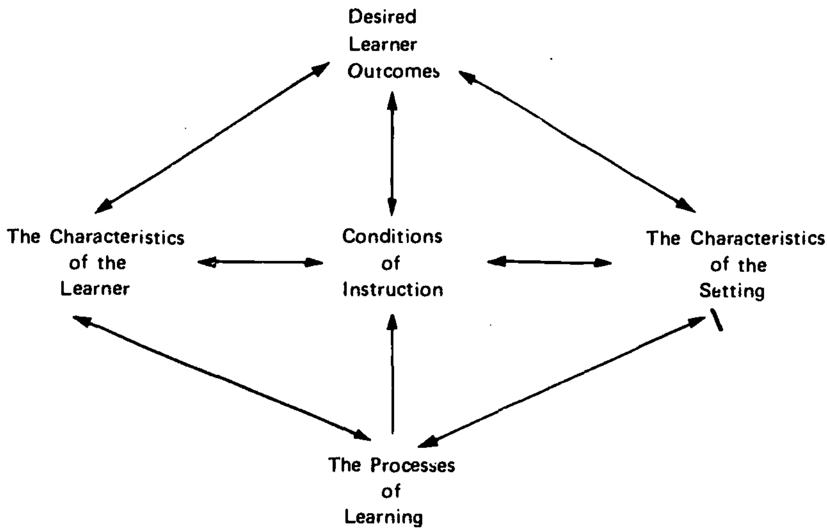


Figure 19. **A schematic of the factors that need to be considered in establishing the conditions of instruction at a given point in time.**

Historically the conditions of instruction have involved the interplay between two major parameters, instructional materials (curricula) and instructional procedures (methods). These parameters seem to be as relevant today as they have ever been and consequently will serve as the basis for organizing the present review. Considerably more detail is given to instructional procedures in the review than instructional materials, for the behavioral sciences traditionally have had much more to say about this area. As in previous sections of the paper, the review of existing literature appears as Supplement 4. In an effort to be consistent with that which has been written thus far, the review of methods is organized around the contributions of educators, personality theorists and ego psychologists, educational and or learning psychologists, training psychologists and the cyberneticists.

Instructional Content, Instructional Operations, and Learner Outcomes: Three Dimensions of a Model to be Considered in the Design of Instructional Experiences

At this point the efforts come full circle, for the task here is to relate the conditions of instruction to that which has been outlined in the two previous sections of the paper, namely, learner outcomes and learning processes. Ultimately of course the conditions of instruction must also be related to the characteristics of learners and the characteristics of the setting in which learning is to take place, but for the present the conditions of learning will be related only to the first two components of the instructional matrix. The task can be illustrated schematically once again by altering slightly that which was outlined in Figure 1. This is illustrated in Figure 20. As used here the concept of instructional content refers to the *substantive dimension of instruction*, that is, the facts, concepts, principles, plans, etc. which make up a subject matter; the concept of instructional operations refers to the *process dimension of instruction*, that is, the strategies, tactics and moves that a teacher uses in facilitating mastery of the substantive dimension of instruction. Instructional content and operations, which correspond roughly to the older concepts of instructional materials and methods, are key concepts in the present analysis, and will be described in some detail later. The critical difference between the concepts of content and operations, as these are used here, and the concepts of materials and methods, is that *the former are defined behaviorally*.

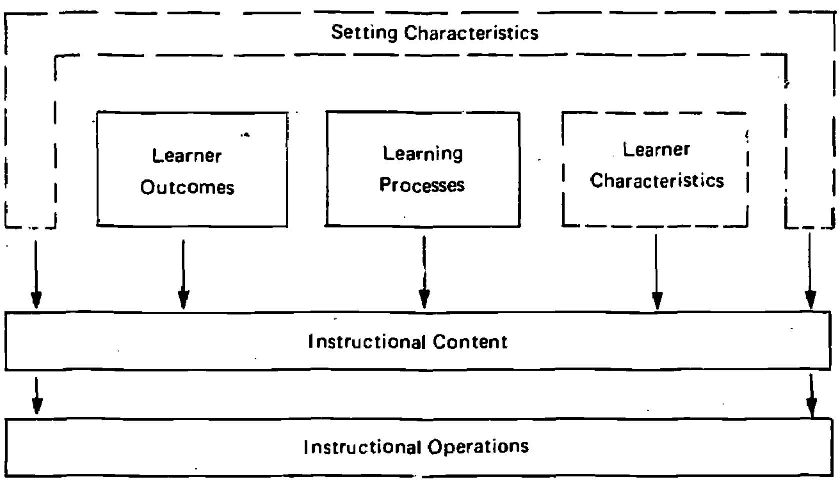


Figure 20. A schematic organization of the variables that need to be considered in the design of instructional experiences. The variables boxed in unbroken lines are those to be considered in the present paper.

In attempting to relate the condition of instructional content and operations to learner outcomes a sequential model will be used that looks much like that employed by the training psychologists in their work. Broadly conceived the model involves 1) the specification of target outcomes, 2) the specification of the prerequisite skills or understandings needed to perform the target outcomes, and 3) the specification of the instructional conditions that will bring about both the needed prerequisite and target outcomes. A schematic of the model appears as Figure 21. At this point the model involves only the taxonomy of learner outcomes developed in section 1 of the paper and the concepts of instructional content and instructional operations; the constraints imposed on the design of instructional experiences by what is known about the nature of learners or the nature of the learning settings have not been built into the model. Constraints imposed by what is known about the learning process have to be taken into account in the specification of instructional content and operations.

Step 1 in the model: Specification of target outcomes. As indicated in section 1 of the paper, the specification of target outcomes requires three major steps: a) identification of what the outcome in fact is to be, b) describing the outcome in behavioral terms, that is, describing it in terms of its focus, form and content (see Figures 9 and 10), and c) classifying the outcome in terms of the taxonomy of outcomes, as this appears in Figure 11. This corresponds to step 7 in Dr. Hamreus' flow diagram for the development of instructional systems.

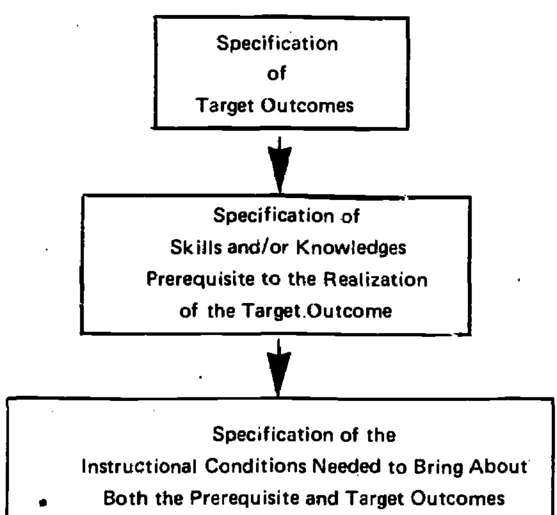


Figure 21. A schematic of the sequential model to be used in attempting to relate the conditions of instruction to learner outcomes.

Identifying Target Outcomes. This requires that in some way or another that which one wishes to accomplish or bring about as a consequence of an educational experience be known and can be explicated. These may be given by an authority, arrived at independently or derived from an extensive task analysis, and they may take any degree of specificity or generality, for example, they may range from spelling a word correctly to wiring a computer board without error to developing a feeling of confidence in a given situation. The critical element in this step of the process is that, by whatever means, the outcome desired is identifiable.

Describing Target Outcomes Behaviorally. This requires that the target outcome be described with a set of behavioral referents so that all who must deal with the target outcome can be clear as to its meaning. The procedure suggested in the first section of the paper requires that the objective be described in terms of its focus, form, and content, but that is all. *It does not require that the criteria that will be accepted as evidence of the objective having been achieved be included in the description of the target outcome,* though as Schalock (1967) has indicated, they must be developed in time in order to make research on the objective or an instructional system designed to bring the objective about operational.

Classifying Target Outcomes in Terms of the Proposed Taxonomy of Learner Outcomes. As soon as one knows clearly what the target outcome is to be, and has defined it behaviorally, the third step in the specification process is to classify the outcome in terms of the proposed taxonomy of outcomes. Operationally this means that one needs to specify a) the domain of human functioning that is represented by the outcome (Vital, Generative, Cognitive), b) if it falls within the cognitive domain then specify the adaptive system within which it falls (Psychomotor, Intellectual, Attitudinal), c) specify the element of cognitive structure that it represents (discrimininination, association, concept, principle, plan), and finally, e) specify the comprehension, understanding or application. As indicated elsewhere, *the basic assumption underlying the specification of outcomes in terms of the proposed taxonomy is that the instructional conditions needed to effectively bring about various kinds of outcomes will vary according to the classification of outcomes on the taxonomy.* If this is true, the implications for the instructional designer are clear: not only must he specify and describe behaviorally the nature of the target outcome but he must also be aware of and design into his instructional experience that which is known of the relationship between the conditions of instruction and the realization of given classes of outcomes.

It is at this level that the training psychologists and instructional systems designers have failed to be explicit, for they have proceeded to design sets of instructional experiences essentially on the basis of reason or logic or experience rather than on the basis of principles underlying the relationship between various sets of instructional experiences and various classes of learner outcomes. It is also at this level, however, that information is most limited. In this respect the systems designers have little choice but to do as they have been doing. The hope for the future, however, is that this kind of information will become available, and th..t it will appear in a form .hat is useable to persons responsible for designing instructional experiences. Operationally, the pursuit of this kind of information constitutes the central focus of a science of instruction.

Step 2 in the model: Specification of competencies that are prerequisite to the realization of the target outcomes. As indicated earlier, one of the major contributions coming from the work of the training psychologists has been the explication of the basic notion that a learning objective or target outcome can be performed only to the extent that all of the skills and or knowledges subordinate to it are also in the repertoire of the learner. This requires that in order to guarantee that a target outcome will in fact be realized there must be a careful hierarchical analysis of the skills and/or knowledges prerequisite to it and the development of effective instructional systems to bring them about. Such an analysis constitutes the second phase of the instructional design sequence and involves the application of a hierarchical analysis of the target outcome or terminal objective into the various levels of subordinate or prerequisite or enabling objectives required for its realization. This corresponds to step 8 in Dr. Hamreus' flow diagram. The procedures to be followed in this process have been outlined in detail by Gagne (1965); Twelker (1967), and others.

Central to the concept of hierarchical analysis is the idea that instructional programs will have to be designed to help the learner master many of the subordinate competencies required to master the target outcome. Given this point of view it follows that *once the subordinate objectives are specified they must then also be defined behaviorally and classified in terms of the proposed taxonomy*. Operationally this demands that the last two steps of the specification procedure outlined in the paragraphs above be applied in all their detail to the subordinate outcomes or enabling objectives with which one must deal. The rationale for such a procedure is straightforward: if one needs to build instructional systems and assessment systems in relation to given classes of learner outcomes, maximal utilization of that which is known of the relationship between the conditions of instruction and the development of given sets of outcomes needs to be utilized.

Step 3 in the model: Specifying the instructional conditions that have the highest probability of bringing about the desired outcomes. The task of the instructional designer in this phase of the specification process is to identify the specific instructional content and the specific set of instructional operations that have highest probability of bringing about the desired learner outcomes for a particular learner under a particular set of conditions. As indicated above the assumption is that classes of learner outcomes, as defined by the proposed taxonomy of learner outcomes, are brought about by relatively well defined, idiosyncratic sets of instructional content and instructional operations. Thus, it is assumed that the content and operations used in instruction to bring about Cognitive outcomes are essentially different than those used to bring about Generative or Vital outcomes. Similarly, it is assumed that different instructional content and operations are required to bring about Psychomotor, Intellectual and Attitudinal outcomes within the cognitive domain. Carrying the analysis further, it is also assumed that different content and operations are required to bring about substantive and process outcomes within either the Psychomotor, Intellectual or Attitudinal system, and that it requires different content and operations to foster each of the various elements of cognitive structure. Finally, it is assumed that different instructional content and operations are required to bring about different levels of cognitive functioning. Operationally, this set of assumptions depends on the possibility that learner outcomes can be identified in terms of their relationship to a rather complex taxonomic scheme and that instructional conditions can be identified that are effective in bringing about the various classes of outcomes for various classes of learners under various classes of settings.

Unfortunately, at this point in time there is no clear evidence that these possibilities exist. With a few exceptions (Gagne, 1965) (Lumsdaine, 1964) educators or educational psychologists simply have not addressed themselves to the relationship between specific sets of instructional conditions and specific sets of learner outcomes, let alone those classes of outcomes that have been specified in the proposed taxonomy. In fact, they have not even begun seriously to develop a framework for the analysis of content, at least as Bruner conceives of the task, or instructional operations. Essential to the development of a firm knowledge base in the field of instruction is the specification of the relevant components of the instructional process and then undertaking a massive and systematic program of research to determine the relationships between these components of the instructional process and given sets of learner outcomes.

If this analysis is at all accurate, the task facing the educational psychologist is twofold: 1) develop the constructs and/or taxonomies that permit research on the issues of instruction-learning to proceed with some degree of power, and 2) initiate the programs of research needed to establish the relationships between the conditions of instruction and classes of learner outcomes. Hopefully, the present paper contributes to the first task.

This whole strategy, of course, rests on the assumption that there is some systematic relationship between classes of instructional content, operations, and learner outcomes. While this is highly probable, since instruction has been able to be ordered with some degree of effectiveness and patterns in instruction are recurrent, there is no guarantee that there is. If there isn't such a relationship, however, the task of the instructional designer is relatively hopeless, for each outcome to be developed would require an essentially different set of instructional experiences to bring it about.

Ideally, if the present section of the paper were to follow the lead of the other sections of the paper, a first approximation to the conceptual frameworks needed to pursue such a program of research would be outlined. Two factors make this impractical: 1) there isn't space or time, and 2) only a framework which outlines instructional operations has been developed. This framework will be reviewed briefly in the closing paragraphs of the paper. Systems for the analysis and ordering of the content of instruction must come from persons within the disciplines themselves or from curriculum specialists.

The design of a system to study instructional operations. Over the past five years staff at Teaching Research have been involved in the development of a conceptual framework that can be used in the detailed analysis of teaching operations. This framework has been translated into an observation system, known as the Teaching Research System for the Description of Teaching Behavior in Context that is now functional (Schalock, 1967) (Schalock, Micek, and Weigel, 1968). In essence the system represents an effort to develop a conceptually sound, relatively exhaustive measure of teaching behavior and the contextual variables which influence it. In developing the system, advantage has been taken of the work of others who have been interested in describing teaching behavior, for example, Hughes (1959), Flanders, (1960), Taba (1964); the work of Bales (1950) in the study of small group interaction; and the work of Bishop (1951), Moustakas, Sigel, and Schalock (1956), and Schalock and O'Neill (1960) in the study of parent-child interaction. An effort has been made in the present system, however, to move beyond these previous efforts and to overcome many of their limitations (Schalock, 1967).

The TR System is relatively exhaustive as a measure of classroom interaction in that it provides a detailed description of a) the instructional strategies used by teachers, i.e., the sequencing of instructional tactics and/or moves in providing information, precipitating a response or offering corrective feedback, b) the management strategies she uses, i.e., the sequencing of organizational and control behaviors, c) the effective setting within which instruction and management occur, and d) the classes of student behavior which precipitate a teacher's behavior or which are given in response to her behavior. The system takes as its data base both the verbal and non-verbal aspects of interaction and it provides a detailed record of the setting variables that are relevant to teacher and/or student behavior, eg., a running record of the activity in which the class is involved, the characteristics of the classroom, and the occurrence of unusual events which vary the ordinary routine of a classroom. Live classroom observers and tape recordings are combined for purposes of data collection. In this way, the complex, subtle, and non-verbal aspects of classroom interaction can be obtained through the live observer while the detailed verbal interaction can be obtained through the analysis of the tapes.

A brief description of the system, the nature of the data that derive from it, and evidence as to its reliability and validity are available in monograph form for those who would like to have it. A training manual, complete with training exercises, films, etc., will be available shortly for those who wish to use it for research purposes. For what it's worth, *the system is tied closely to the theory of human development that served as a basis for the taxonomy of learner outcomes outlined in the first section of the present paper, the processes of learning outlined in the second section of the paper and the conditions of learning as outlined in the third section of the paper.*

Implications for Instructional Design

The implications of the present section of the paper for the designers of instruction are clear, though incomplete: 1)they must specify the target outcomes toward which the instructional system is to be directed; 2) they must specify the prerequisite skills or understandings needed to perform the target outcomes; and 3) they must design the instructional system so as to reflect that which is known about the relationship between specific sets of instructional conditions and specific set of learner outcomes. This is not to imply that the systems designer is expected to perform these various tasks himself; generally speaking, others on the educational team will have to determine target objectives, hierarchical structure, and the relevant instructional principles. *The instructional designer is responsible, however, for insisting that he has all three classes of information at his disposal before he undertakes the development of an instructional system.* The steps required in order to obtain the kind of information needed are summarized in Figure 22.

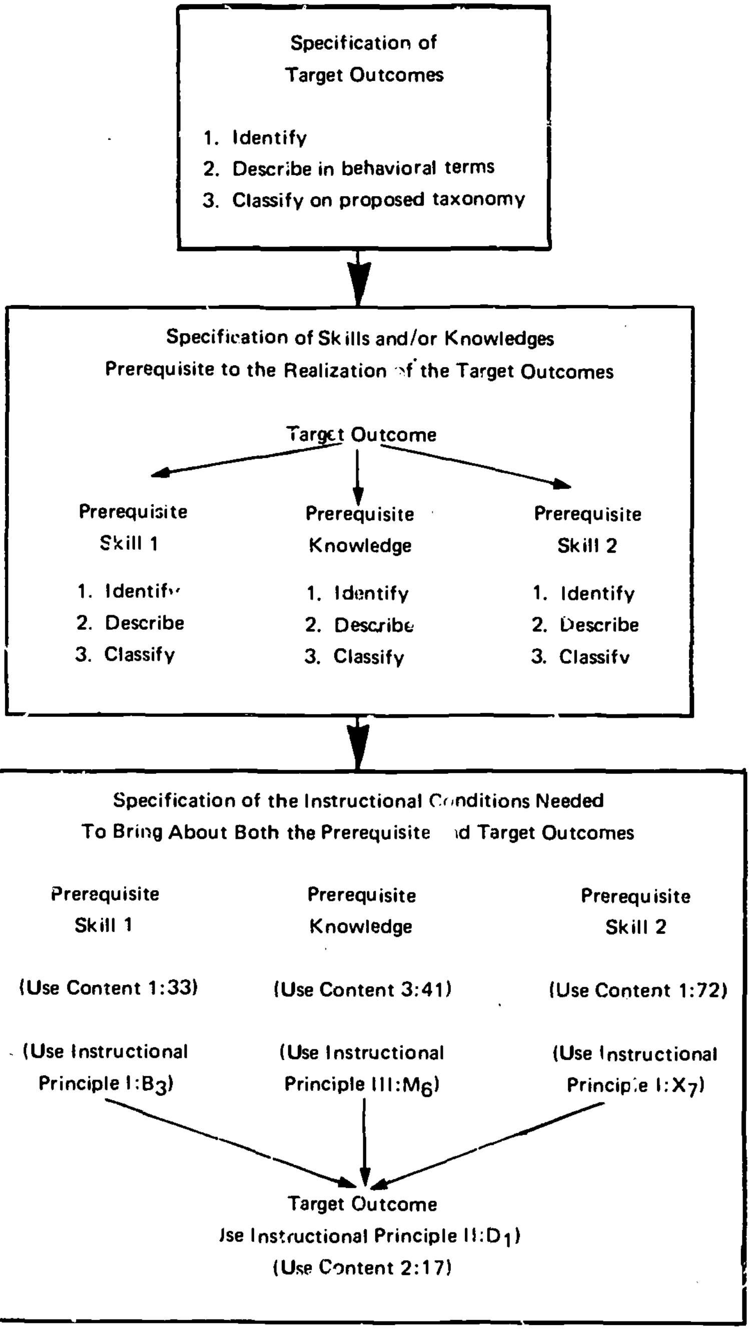


Figure 22. A summary of the steps to be taken in preparation for the development of an instructional system(s).

Issue 12: Is the idea that specific classes of learner outcomes require specific sets of instructional content and operations for their development a reasonable one?

Issue 13: Assuming that specific content and operations do need to be linked to given classes of outcomes, do you think it feasible or even possible for a science of instruction to ever identify those?

Issue 14: Assuming that a science of instruction made it possible to specify the relationships between outcomes, content and operations, do you think it possible to train classroom teachers to the point where they could profitably use this information in their day-to-day teaching?

Issue 15: Moving beyond the issue of relationship between outcomes, content and operations, do you think it possible to train classroom teachers to the point where they could perform the detailed hierarchical analysis of target and prerequisite outcomes required " this approach to instruction?

Issue 16: Do you think that Bruner's concept of structure of a discipline" is valid?

Issue 17: A plea is made in the present paper to define instructional operations in terms of concrete observable, specific instances of behavior. Do you think that it will ever be possible to find a way of conceptualizing and studying overt teaching behavior in the detail and with the rigor that will be required to develop a science of instruction?

Issue 18: is the position taken in the present paper with respect to the behavioral definition of objectives, that is, that such definitions do not require the specification of the criteria by which to assess whether the objective has been reached, a valid one?

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Supplement 1

A Review of Taxonomies of Learner Outcomes

Six orientations to the development of taxonomies of learner outcomes are reviewed in the pages which follow: 1) that of developmental psychologists, 2) that of personality theorists, 3) that of psychoanalytic or "ego" psychologists, 4) that of educators, 5) that of learning psychologists, and 6) that of "training" psychologists.

Classes of Learner Outcomes as Seen by Developmental Psychologists

Historically, developmental psychologists have been concerned with the full range of human development, and have tended to use as their guide to instruction and practice such broad category headings as physical development, social development, emotional development, and intellectual development, or slightly less general headings such as motor development, speech development, moral development or personality development. More recently chapter headings such as "The Acquisition of Sex Typing and Sex Role Identity" or "The Attainment of Concepts" or "Productive Thinking" have found their way into the literature, but generally speaking developmental psychologists have not been serious in working out a taxonomy of learner outcomes beyond those representative of chapter headings.

Two exceptions to this rather sweeping generalization are Erikson (1963) and Piaget (1967), but neither of the taxonomies developed by these men is appropriate for review here. While both are considered developmental psychologists, their taxonomies do not deal with developmental outcomes that are of a learned nature. Erikson's focus is upon stages in the personality development of the organism and Piaget's is upon stages in the intellectual development of the organism, and as such both are dealing primarily with genetically determined rather than learned sequences in development. Within the structure of the present symposium both are more properly handled by Dr. Beaird in his treatment of learner characteristics.

Classes of Learner Outcomes as Seen by Personality Theorists

By and large, personality theorists have tended to develop taxonomies of learner outcomes that fall into what might be called the "middle range" of generality: they are less general than those typically used by developmental psychologists but considerably more general than those typically used by learning theorists. In many ways they are of approximately the same level of generality as those used by educators; in fact, they are often adopted by educators.

Two major groupings of taxonomies have evolved from the work of personality theorists which have had an impact upon education, those coming from the mental health or mental hygiene movement and those coming from the phenomenological emphasis of recent years. Learner outcomes typically of concern to the mental hygienists include freedom from extreme frustrations, fears, anxieties, phobias, etc., a balance of constructive feelings about oneself, and interpersonal orientations which permit constructive friendship, love and work relationships. Learner outcomes typically of concern to the phenomenological psychologists include a "positive view of self," "identification with others," "openness to experience and acceptance," "a rich and available perceptual field" (Combs, 1962), "self actualization" (Maslow, 1954, 1962), "an increasing openness to experience," "becoming a process," "an increasing trust in one's organism" (Rogers, 1961), "A fully functioning self" (Kelley, 1962). The 1962 Yearbook of the Association for Supervision and Curriculum Development, *Perceiving, Behaving, Becoming*, contains an excellent synopsis of the class of outcomes.

Classes of Learner Outcomes as Seen by Psychoanalytic or "Ego" Psychologists

In many ways there is little basis for distinguishing between the psychoanalytic or "ego" group and the personality theorists just reviewed: they are both concerned with healthy personality development and they both engage in clinical or therapeutic activities. There is a sharp distinction in both the concepts and procedures used by these groups, however, and thus the distinction suggested here. In contrast to the "phenomenological" psychologists, the "ego" psychologists use the concepts of ego functions or ego processes in their reference to learner outcomes(Hallister and Bower, 1966) (White, 1963). As conceived by Bower (1966):

> ...ego processes are data processes, i.e., they pick out of the environment those objects, ideas and feelings which have survival value, "process" them, and respond to the processed data. At a higher level of abstraction, ego processes can be regarded as ways in which each individual has learned to manage himself and his environment to produce the highest survival benefit to himself. Or one can conceptualize ego processes as the organization of the personality of an individual related mainly to the perceptual system which acts as a mediator and interpreter of the external world and as a mediator of the individual himself (p. 109).

As such, ego psychology is centrally concerned with the use of symbols (Werner and Kaplan, 1963).

Hollister and Bower (1966) outline five specific dimensions of ego processes:

(1.) Differentiation vs. confusion: the processes by which objects, events and feelings are separated out and perceived clearly.

(2) Fidelity vs. distortion. the processes by which objects, events and feelings are seen and reproduced faithfully as they are experienced.

(3.) Pacing vs. over- or underloading: the processes by which objects, events and feelings are attached to appropriate emotional loads and stresses.

(4.) Expansion vs. constriction: the processes by which new symbols, or new meanings for old symbols, are assimilated and used.

(5.) Integration vs. fragmentation: the processes by which symbols are processed within the individual as a whole rather than in one or another separate compartment.

Sullivan, Grant and Grant (1957) provide a different list, but be this as it may, ego theorists are beginning seriously to develop taxonomies of ego functions with the aim of their having utility in the field of education. While the effort is only beginning, the utility of the concepts used by these psychologists in the field of therapy and mental health suggests that they bear attending to by educators.

Classes of Learner Outcomes as Seen by Educators

As implied above, educators at one time or another have used nearly all of the taxonomies and learner outcomes that have been developed in other disciplines. In addition they have always had the subject matter taxonomies that have made up the traditional school curriculum. Sometimes these have been put together formally (cf. Figure 2), but by and large they have been used in relatively disparate, disjointed ways. Within subject matter areas, of course, a great deal of attention has been directed to classes of educational objectives.

Within recent years educators, or psychologists concerned with educational problems, have become serious about the development of their own taxonomies of educational outcomes. Most of this thinking has been focused upon what has been labeled "cognitive" or intellective outcomes, but some effort has also been directed to the "affective" or feeling and "psychomotor" areas.

Cognitive Outcomes. Generally speaking, cognition is defined as that which permits an organism to become aware of or obtain knowledge about his external world and apply this knowledge or awareness in his

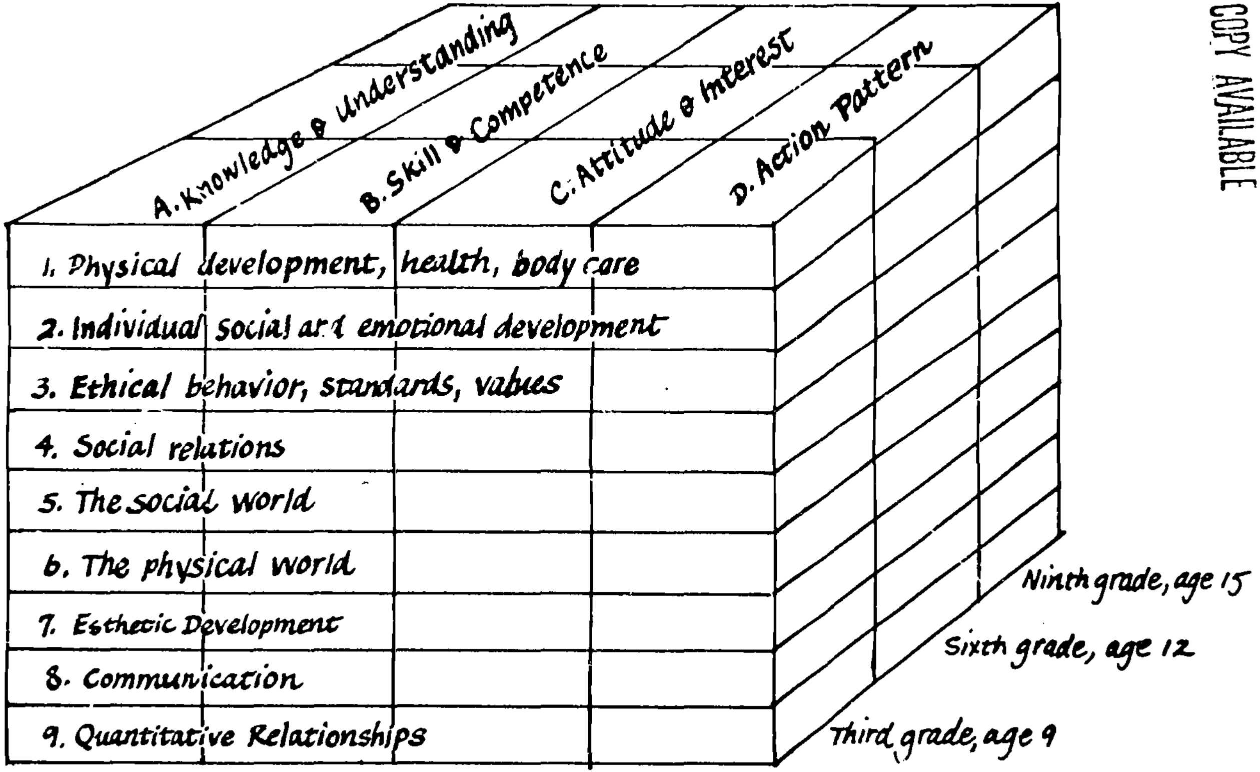


Figure 2. The behavioral continum, showing broad curriculum areas intersecting major behavior categories. (From N. C. Kearney, Elementary School Objectives. New York: Russell Sage Foundation, 1953, p. 38)

relations to it (English and English, 1958) (Scheerer, 1954)[1]. The function of cognition is that of permitting the organism to know or to be aware of or to understand the objects, events and processes which are encountered in the course of living, and thereby be able either to control them or his relationship to them (Smith and Smith, 1966). In this sense cognition serves a major adaptive function for the organism.

In conceptualizing cognitive outcomes, a useful distinction has been introduced between cognitive outcomes which focus upon *content* and those which focus upon *processing*. In a recent publication (1966) Gage defines cognitive content as "...various kinds of knowledge -- defined as ability to recall or recognize facts, definitions, laws, and so on..." and cognitive processes as "...various kinds of intellectual arts and skills, such as the ability to analyze, evaluate, synthesize, translate, interpret, and so on." (p. 30). By and large current writers in the area are in agreement with Gage's definitions. For example, Taba and her associates (1964), after an exhaustive review of the literature in the area of cognition, identified three major categories of process: 1) grouping and classification of information, 2) interpretation of data and the making of inference, and 3) the application of knowledge principles and facts to explain a phenomenon, to predict consequences of known conditions and events, or to develop hypotheses by using known generalizations and facts. Bloom (1956) has identified five categories of process: 1) comprehension, which includes translation, interpretation, and extrapolation, 2) application, 3) analysis, 4) synthesis, and 5) evaluation.

Perhaps the best known taxonomy of cognitive outcomes making use of the distinction between content and process is that proposed by Guilford (1959). He has developed a model which reflects what he terms "the three faces of intellect," incorporating simultaneously into the model three intellectual factors which he calls *operation*, *contents*, and *products*. By way of definition, Guilford looks upon operations as intellectual activities or processes, that is, things that the organism does with the raw materials of information; on contents as broad classes of information stored by the individual; and upon products as the form that that information takes. Each of these factors has a number of subdivisions, and when combined provide a matrix which permits 120 possible human abilities in the cognitive domain. Again, as a point of reference, Guilford's model is reproduced as Figure 3 (after Kalusmeier and Goodwin, pg. 36).

While Guilford's model represents a remarkable increase in sophistication in conceptualizing cognitive outcomes, two criticisms can be leveled at it. The first has to do with the unevenness or the inconsistencies

[1] For purposes of the present paper the concept includes sensation, perception, volition and action, though technically (see Attneave, 1962) it should not.

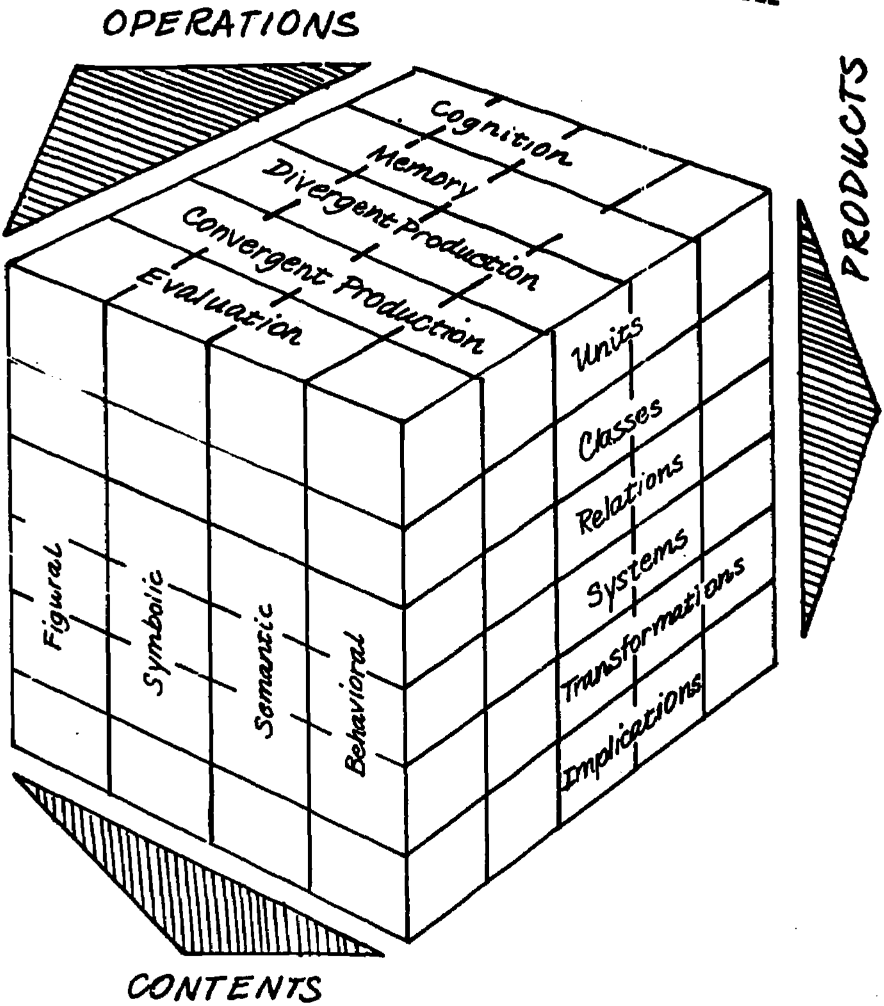


Figure 3. Model of the structure of the intellect. (Adapted from J. P. Guilford and R. Hoepfner. Current summary of structure-of-intellect factors and suggested tests. Rep. Psychol. Lab., No. 30. Los Angeles: University of Southern California, 1963. P. 2)

which appear within the taxonomy of products and the taxonomy of operations. For example, while the first four elements within the products taxonomy relate logically to one another, and form a hierarchy, the last two elements within the taxonomy seem to be of quite a different nature. Also, the last two elements differ from each other in the sense that transformation requires the modification or reintegration of knowledge, and implications involve the making of predictions or the drawing of extrapoltions from given information. Similarly with the operations taxonomy: cognition and memory seem to be of a piece while divergent production, convergent production and evaluation seem to be representative of a different class of operation. It also seems, on the surface at least, that transformations and implications from the products taxonomy coincide more closely with the elements of the operations taxonomy than they do with the first four elements within the products taxonomy.

The second criticism that can be leveled at the Guilford model, as well as the other taxonomies that have been reviewed, is that it fails to tie to the learning literature. This seems hard to understand since cognitive development comes about through learning and since we probably have more firm data about learning than we do about any other aspect which has to do with cognitive development. It seems odd also that cognitive outcomes have never been conceptualized in terms of structure. This is a concept which pervades all other sciences, and it would seem that a framework dealing exhaustively with cognition would have to include such a concept.

Affective Outcomes. Historically, the term affect has served as a class name for feeling, emotion, or mood (English and English, 1958). As such, the concept has a great deal of relevance to the educational enterprises for it is clearly recognized that the feeling dimension of the learning process is as critical as the cognitive dimension, and that affective outcomes are as relevant as cognitive outcomes when considering educational objectives. As educators have come to use the term, however, its historical meanings have become so entwined with the concepts of motivation, attitudes, values and beliefs that as a term it no longer has any clear meaning. This is reflected in the only serious attempt that has been made by educators to develop a taxonomy of the affective domain (Krathwohl, et al., 1964) and probably accounts for its relatively limited use within the field thus far. The confusion inherent in the taxonomy can be seen in its headings: Receiving (awareness of others, willingness to receive information), Responding (acquiescence in responding, willingness to respond, satisfaction in response), Valuing (acceptance of a value, preference for and commitment to a value). Organizing (conceptualizing a value and organizing a value system), and Characterization by a Value or Value Complex. Unfortunately, until there is clarification of concepts within the area, it is unlikely that educational practice will reflect a systematic program directed to the development of such outcomes.

Psychomotor Outcomes. Historically, psychomotor outcomes have referred to perceptual-motor skills such as walking, running, manual dexterity tasks, etc. Current literature (Fitts, 1964) broadens the concept so that any behavior that involves sequentially organized action patterns fits the definition. Thus conceived, distinctions between verbal and motor outcomes or between cognitive and motor outcomes disappear. Even so, for convenience, educators and psychologists continue to treat them as if they were separate classes of outcomes, and they will be so ordered here.

Surprisingly, considering the long history of experimental work on the topic and the emphasis given to athletics and recreational activities by the public schools, educators have done relatively little toward the development of a functional taxonomy of psychomotor outcomes for use in the schools. Two recent efforts along this line are those by Fleishman (1965) and Livingston (1966). Also, Guilford (1958) has identified six psychomotor factors which he believes to be involved in any kind of motor performance, but these do not represent a taxonomy of psychomotor outcomes in the sense that the term is being used here. While there is a beginning of work in this area, it is likely that educational practice will lack clarity and direction with respect to psychomotor outcomes until concepts in the area have been clarified or the currently available taxonomies have been tested.

Classes of Learner Outcomes as Seen by Learning Theorists

In considering the kinds of learner outcomes generated by different professional groups concerned with education, those developed by learning theorists are at one and the same time some of the most specific and some of the most general to be found. By and large the outcomes learning theorists deal with are relatively narrowly defined and largely contentless classes of behavior, for example, discriminations, associations, concepts, and principles. While these are rather "narrow" categories of behavior, they are also general for they are assumed to crosscut all learning. Thus, the acquisition of the discriminations, associations, concepts, etc. required in learning to read is thought to follow the same processes as the acquisition of the discriminations, associations, concepts, etc., required in learning to walk or write or play a musical instrument. It is in this sense that learning theorists are seeking general laws of learning: if the formation of these general classes of outcomes is essential to all performance, and if the various classes of outcomes are formed in essentially the same manner, the basis for effective instructional practice would be established.

Unfortunately, as indicated earlier, the work of learning theorists has thus far not had the kind of impact upon educational practice that it has the potential of having. Estes, writing on "Learning" in the *Encyclopedia of Educational Research*, feels that "...no convergence is imminent between the educator's and the laboratory scientist's approaches to learning ..." and that there are no clear indications of efforts "...toward bridging the gap between laboratory psychology and the study of school learning" (Estes, 1960, p. 767). This statement was made nearly 10 years ago, and while it is still essentially true, there are indications that the circumstance has some chance of changing.

The most hopeful sign of change is the growing recognition that the traditional categories of human learning are limited, confused and confusing (Deutsch, 1960) (Melton, 1964) (Wann, 1964) (Bruner, et al., 1964), and that a more functional taxonomy of learning outcomes needs to be established. Melton makes the point well:

> ...our elementary text books in psychology, which are presumed to treat the fundamentals of the science, are quite confused and confusing with respect to these traditional categories of learning. While most of them make the distinction between rote learning, skill learning, and problem solving, these categories are functioning chiefly as class names defined by pointing to some familiar laboratory or real-life examples. Even when the point is made that examples from different categories have similarities that might be the basis for intercategory similarities...there is no attempt to show that such is the case... The net result has been a paucity of systematic thinking and writing about the full range of human learning and the possible basis on which this variety could be more meaningfully and validly categorized in terms of processes, phenomena, or the effects of variables.
>
> The most certain conclusion that one can reach about the traditional categories is that they are not the proper categories for use in understanding human learning even though they may serve a useful denotative function. The best that can be said for them is that each category does include a task aspect of behavior requirement which is important and is given heavy weight or emphasis in at least some of the subcategories within it. (pp. 332, 333)

The second hopeful sign is that several major efforts at developing such a taxonomy have been made, though by and large these have stemmed from the work of "training psychologists" rather than the traditional "learning psychologists." While the distinction between these two groups of scientists is somewhat artificial, the focus and history of their work has been sufficiently different to lead to a rather sharp distinction in the minds of many.

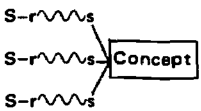
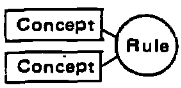
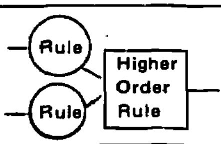
Classes of Learner Outcomes as Seen by Training Psychologists

The term "training psychologists" refers to a rather large group of scientists working on problems of education and training within the context of the military and industry. Relatively unknown to many educators this group of psychologists constitutes one of the major research and development thrusts within education within the past 15 years. While it is difficult to identify the number of persons working on education-training problems in industry the numbers are well known in the military complex: in 1963, those in the Human Resources Research Office (HumRRO), the training research and development arm of the Chief of Army Research and Development, numbered 100, 65 of whom were Ph.D.'s, and those employed in the Air Force Training and Research Center, in operation from 1949 to 1958, employed approximately 168 psychologists at its peak, 100 of whom held Ph.D.'s. Two reasons underlie the general lack of awareness of the contribution of this group of psychologists: 1) by and large the reports of their work have become available to the educational and psychological profession only recently, as most of their initial reporting was either classified, published in limited circulation reports, or published in little-read journals, and 2) the concept of training is at odds with many educators' notion of the role or function of education, with the consequence that research associated with the concept is often shunned or relegated to the "irrelevant." This latter problem is largely one of definition, and with the passage of time has essentially resolved itself. Glaser provides the following distinction between training and education:

> Training and education are two aspects of the teaching process. The two terms refer to two classes of teaching processes that are not mutually exclusive. Certain dimensions which form the continuum along which the distinctions fall are specificity of behavioral goal, and uniformity versus individual development. Although one may wish to distinguish between "training" and "education" in terms of behavioral goals, and the method of attaining them, the technological processes required to carry out either are built upon principles for modifying, developing and guiding behaviors that are generated from behavioral research. In the various definitions of the two verbs "to train" and "to educate," the underlying similarity is "to develop or form by systematic instruction." The term "instruction" seems to be a word which can refer to the general operations with which both training and education are concerned. (1962, p 5)

Perhaps the major circumstance that has led this group of psychologists to contribute so significantly to the solution of the issues facing education is the fact that they have been task oriented, that is, they have had to produce results that made a significant difference in training of men, and the tasks which they were concerned with were tasks of a highly complex, "real-life" nature. Out of their work with tasks of this nature has come a number of relatively sophisticated taxonomies of learner tasks (Demaree, 1961) (Parker and Downs, 1961) (Miller, 1960) (Willis, 1961) (Cotterman, 1959) (Lumsdaine, 1960) (Stolurow, 1963). Contributing to the Melton volume, and subsequently his book *The Conditions of Learning* (1965), Gagne also has outlined a suggested ordering of the types of human learning that seems to be particularly powerful. Figure 4 contains a summary of Gagne's taxonomy as it appeared in the Melton volume, modified by the addition of examples from Klausmeier and Goodwin. In its expanded form the taxonomy contains eight types of learning: Signal Learning, Stimulus-Response Learning, Chaining, Verbal Association, Multiple-Discrimination Learning, Concept Learning, Principle Learning and Problem Solving.

In the opinion of many Gagne's contribution represents the first major bridge between the work of the laboratory psychologists and the work of the classroom educator, and as such has created a great deal of excitement within both the psychological and educational professions. I share this opinion, but I see Gagne's contribution as representing only part of the task. There is in addition the matter of fitting the classes of outcomes Gagne suggests with other classes of outcomes, for example, the process and content outcomes suggested by Bloom or Taba or Guilford, and the broad developmental outcomes suggested by the developmental psychologists and personality theorists. The aim of the next section of the paper is to offer a two-level taxonomy of learner outcomes as an initial approximation to that integration.

Type	Paradigm[1]	Description	Example
Response learning	S–R	Establishment of a response-connection to a stimulus specified along physical dimensions	Contact with fire (S) elicits startle movement (R)
Chaining	S–R~S–R	Establishment of chains of response connections	Above paradigm is chained to presentation of heat (S) which elicits withdrawal (R)
Verbal learning (paired associates)	S–r∿∿∿[s–R]	Establishment of labeling response to stimuli varying physically within limits of primary stimulus generalization. Previous "response learning" assumed (as indicated by brackets)	Contact with first (S) is associated with feeling of heat (r) and word HOT (R) (Association of heat sensation as s with word HOT as R assumed)
Concept learning		Establishment of mediating response to stimuli which differ from each other physically ("classifying")	Association of fire (S) steam (S) and hot metal (S) with feeling of heat (r) leads to association of heat with concept HOTNESS
Principle learning		Establishment of a process which functions like a rule "If A, then B," where A and B are concepts	Concepts HOTNESS and SHARPNESS (similar paradigms assumed) lead to rule: "If hot or sharp, then painful"
Problem solving		Establishment of a process which "combines" two or more previously learned rules in a "higher-order rule"	Solving "if water boils at 212° F, at what C does it boil, given F=9/5C + 32"

[1] The paradigms shown have been designed to depict what is learned, and not the learning situation which leads to this result. In addition, it may be noted that beginning with concept learning, only the central portions of the inferred chains are shown

Figure 4. A suggested ordering of the types of human learning. (Adapted from R. M. Gagne. Problem solving, in A. W. Melton (Ed.) *Categories of human learning.* New York: Academic Press, 1964, p. 312.

Supplement 2

Two Views of the Learning Process: The Behavioral and the Cognitive

Theories of learning are concerned with the conditions that bring about predictable patterns of behavior on the part of the individual. It will be convenient, albeit a considerable oversimplification, to distinguish two major approaches to the study of learning. First, there is the so-called behavioral approach, loosely characterized as the S-R, or reinforcement camp. Secondly, there is the cognitive approach, emphasizing the so-called higher mental processes. Representative positions associated with each of these two approaches will be presented in highly capsular form below.

The Behavioral Approach

The history of the systematic study of learning is usually traced back to the classical experiments in conditioning performed by the Russian physiologist, Ivan Pavlov (1849-1936). Basically, this form of learning depends upon the initial presence of an unconditioned response (or reflex) that is reliably elicited by a particular unconditioned stimulus. The classical example is the salivary reflex that is elicited by food-in-the-mouth. During conditioning trials, the unconditioned stimulus (food) is presented together with a stimulus which is to be conditioned (e.g., a buzzer). Conditioning is said to have occurred when the new (conditioned) stimulus comes to elicit the response that was formerly made only to the unconditioned stimulus. This form of conditioning has been demonstrated repeatedly, with humans as well as animals. A related discovery is the phenomenon of experimental extinction. When the buzzer is repeatedly sounded but the food withheld, the conditioned salivation response will gradually be eliminated. Generalization is another important principle described by Pavlov. Once conditioning has been established, it is not necessary to present precisely the same conditioned stimulus in order to elicit the conditioned response. A similar stimulus will also bring it out.

A second, separate tradition within the behavioral approach is the Thorndikian tradition. E. L. Thorndike (1874-1949) proposed three particularly well-known "laws" of learning: the law of *effect*, through which "satisfiers" and "annoyers" were said to "stamp in" or "stamp out" stimulus-response bonds; the law of *exercise*, proposing that these bonds are strengthened with use and weakened with disuse; and the law of *readiness*, which concerns the organism's capacity to perform the desired response. In one considerably altered form or another, many of the concepts set down by Thorndike are incorporated still in contemporary approaches to learning. Clark L. Hull (1884-1952), in the Thorndikian tradition, is the outstanding proponent of the hypothetico-deductive approach to theory construction and validation in learning. He developed an elaborate set of postulates, mathematical expressions, and symbolic notations. Hull's work is still carried on actively by his one-time colleague, Kenneth Spence. Hull held that whenever a response is followed closely by the reduction of a drive; either physiological or acquired, there will be an increment in the strength of the bond between the response and any stimulus (or stimuli) present at the time the response is initiated. Hull and his associates defined and explored a number of related concepts, such as secondary reinforcement, secondary drive, reactive inhibition, the goal gradient, the fractional antedating response, and the habit-family hierarchy. A major current figure in the Thorndikian tradition is B. F. Skinner. In sharp contrast with Hull, Skinner outspokenly denounces present-day attempts at constructing theories of learning, preferring simply to describe the conditions known to be effective in shaping and controlling behavior. He is noted for his work in distinguishing between classical conditioning and instrumental, or operant conditioning. Operant conditioning is achieved through the process of "shaping up" those responses over which one desires to gain control. This form of conditioning is concerned with "emitted" or "operant" responses. These are distinguished from elicited responses in that they occur in the absence of any recognized stimulus. In shaping up responses, one reinforces a succession of operant responses that are progressively more similar to the desired responses, until eventually the desired response itself comes under control of the reinforcement. Among the important related problems studied by Skinner are the effects of deprivation, the effects of various reinforcement schedules, the conditions for extinction, the role of punishment, and the operation of secondary reinforcement.

O. Hobart Mowrer's recent work in learning represents a convergence of the Thorndikian and Pavlovian traditions. He holds that Pavlovian conditioning operates exclusively through its control over the emotional states associated with the autonomic nervous system, so that, for instance, it is not the salivary response that is conditioned in the case of Pavlov's dog, but the "emotions" associated with the presence of food. The so-called "positive" emotions are characterized generally as *hope*, and the negative as *fear*. Certain increments and decrements associated with changes in the state of these emotions provide the reinforcement conditions for conditionable responses. Both the positive and negative reactions elicited by any stimulus object involved in the learning process may be capitalized upon in bringing about learning.

Robert Gagne has recently proposed a taxonomy of learning principles which distinguishes eight hierarchically organized types. These include, in progressive hierarchical order, signal learning, stimulus-response learning, chaining; verbal association, multiple discrimination; concept learning, principle learning, and problem solving. In general, each successive type of learning depends upon and incorporates the learning that occured in connection with the immediately preceding type.

The Cognitive View

Edward C. Tolman (1886-1959) could actually be included among the behaviorists, since his basic learning paradigm was an extension of classical conditioning, and since he was inclined to integrate his views with those of his behaviorally oriented contemporaries. He chose to insert a number of "intervening variables" between the S and the R in the traditional Stimulus-Response formula (e.g., motivation, past history, expectancies). He interpreted the unconditioned stimulus in the Pavlovian form of conditioning (food-in-the-mouth) as a "significate," and held that through conditioning the conditioned stimulus (the buzzer) became a "sign" of the significate. He spoke of the sign as eliciting an "expectancy" for the significate. He proposed that much of what is learned in any given situation may not be immediately translated into performance, and hence introduced the distinction between learning and performance. This distinction underlies another concept which he introduced, namely, that of "latent learning." The classical example is of rats who perform better in maze-learning experiments with rather than without having previously explored the maze. Confirmations or disconfirmations of expectancies (or "hypotheses") were said by Tolman to build up an increasingly refined "cognitive map" of a given situation.

W. Kohler conducted extensive studies of problem-solving behavior among anthropoid apes. His approach to problem-solving contrasts sharply with the trial-and-error approach propounded by Thorndike. Thorndike worked mostly with cats in "puzzle boxes." These puzzle boxes tended to hide the mechanical devices essential to achieving a solution, thus providing a bias toward a trial-and- error interpretation of problem-solving behavior. By contrast, Kohler devised a variety of situations in which all the components necessary for a solution were openly displayed. In the classical example, the problem is to reach a banana suspended from the ceiling out of reach. Only by rearranging one or more available boxes could the animal obtain the banana. Kohler observed that apes typically made many fruitless attempts in such situations, then, after some point, proceeded quite rapidly and systematically to a solution. He characterized such solutions as "insightful" and attributed insightful solutions to sudden reorganizations, or restructurings, of the psychological field.

An outstanding figure in the area of concept acquisition is Jerome S. Bruner. Bruner defines concepts, or representational categories, as rules for classifying objects as equivalent. Concept acquisition consists of learning the criterial values of attributes which define membership or nonmembership in a representational category; the manner of combination of attributes (e.g., conjunctive, disjunctive, or relational); the weight assigned to various attributes; and the acceptance limits of attribute veriability. The functions of categorizing, or rendering things equivalent, are taken to be these: (a) reducing the complexity of the individual's environment; (b) providing the means for identifying new or familiar objects and events; (c) reducing the necessity for constant learning; directing instrumental activity (i.e., a part of categorizing an object or event consists of making inferences about its uses); (d) permitting classes of events to be ordered and related in various kinds of superordinate systems. Bruner has discovered that different individuals employ different strategies in selecting and processing information during the process of concept acquisition.

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Supplement 3

A Review of Positions Held with Respect to The Nature of the Learning Process

Five positions with respect to the nature of the learning process are reviewed: 1) that of the traditional S-R theorists, 2) that of the traditional S-S theorists, 3) that of the "mediated" S-R theorists, 4) that of the cybernetic or information processing theorists, and 5) that of the neurophysiological theorists.

The Traditional S-R Model

In the eyes of many psychologists the proper subject matter of psychology is what goes into the organism (stimuli) and what comes out (responses); in this view there is no need for and no place for statements describing or making inference to the processes which intervene between what goes in and what comes out. This has often been called the "empty organism" approach to psychology and it is most closely associated with names like Watson (1920), Thorndike (1922), Hull (1943), Miller and Dollard (1941), Guthrie (1950), and Skinner (1957). For these psychologists the relationship between stimulus and response is relatively simple and straightforward. In their early work they tended to model the stimulus-response relationship after the classical psychological pattern of the reflex arc and used Pavlov's findings on the formation of conditioned reflexes (1927) as a basis for all learnings. It soon became obvious, however, that learning was much more than a chain of conditioned reflexes and soon, by attending to the function of stimuli that occur after a response in addition to the stimuli that occur before it, the instrumental conditioning model was added to the classical model. By the addition of the instrumental or operant conditioning model it was possible to account for a much greater variety of behavior than was possible with the classical model, even to the point of accounting for the "purposive" nature of behavior.

The commitment of this group of psychologists to only that which was observable had its history in the tradition of the physical sciences with their insistence that in science one must deal with the observables and postulate as little as possible beyond that. Also this group was strongly influenced by logical positivism with its emphasis upon "explanation" as ultimately no more than a statement of relationships between observed phenomena (Koch, 1964). While most S-R theorists have moved beyond the strictly empirical study of S-R relationships and have incorporated into their theoretical schema constructs that reflect or attempt to take into account the intervening processes, there are some notable exceptions. Foremost of these, of course, is Skinner with his large and active group of followers. Two other works of note are Vokes (1950) in extending the work of Guthrie, and Estes (1950) in his development of a statistical theory of learning.

The Traditional S-S Model

In contrast to the traditional S-R position, a group of learning theorists active during the same years as the early S-R theorists have emphasized the relationship between the stimulus events of the environment and what takes place inside the black box. This group has been known variously as Gestaltists, field theorists; cognitive theorists, or S-S theorists, with the S-S standing for the Sign-Significate-Expectancy concept of Tolman (1932). In addition to Tolman, the names of Kohler (1947), Koffka (1924), Wertheimer (1945), Wheeler (1932), Lewin (1942), and recently Bruner (1964) are associated with the group. The position of the S-S theorists generally is that the effect of an event (stimulus) upon behavior will depend upon how the event is represented in the individual's picture of itself and its universe. They hold that a human being, and probably animals as well, build up internal representations or schema or cognitive maps, or images of the universe in which the individual operates, and that any relationship that exists between incoming stimuli and the individual's response to it must of necessity be mediated by these organized representations of the environment. This view is reflected well in the position of Tolman:

> ...(the brain) is more like a map control room than it is like an old fashioned telephone exchange. The stimuli, which are allowed in, are not connected by just simple one-to-one switches to the outgoing responses; rather, the incoming impulses are usually worked over and elaborated in the central control room into a tentative cognitive like map of the environment. And it is this tentative map, indicating roots and paths and environmental relationships, which finally determines what responses, if any, the animal will finally release. (1948, p. 189)

The issues which separate the traditional S-R and S-S groups are more than theoretical. At odds also are rather fundamental orientations to the nature of human functioning generally. The S-S group tends to look upon the S-R position as a somewhat curious laboratory phenomenon that bears little relationship to the process of learning and functioning under real life circumstances. The difference in the points of view on this account is illustrated vividly by Werthiemer (1945) in his book on *Productive Thinking*. In contrast to his own orientation, which he identifies as focusing "...on developing structural insights, structural mastery, and meaningful learning in the real sense of the word" (page 202) he contrasts the associationist's position as

> ...cases in which the results, the solution, is brought about by sheer chance discovery or merely by a succession of blind trials, by sheer external recall, sheer reliance on blind repetition, by blind drill or by prompting. There are many situations the nature of which fundamentally allows of nothing but blind proceeding and blind finding, for instance, in widely used experiments with mazes, discrimination tasks, and problem boxes. Here all the factors that might furnish some clue to recently directed behavior are carefully excluded by the experimenter. Under these conditions no genius, however great, could at first do anything but engage in blind trials; success could occur only by chance, and then be repeated--unless meanwhile the arbitrary set is changed arbitrarily by the experimenter. (p. 202)

Unlike the S-R tradition the S-S tradition has no active followers today (Hilgard, 1964), at least not in recognizable form. In many ways the increasingly large group of learning theorists aligning themselves with information processing theory continue the S-S tradition (see below). The S-S tradition has also had its impact upon S-R theory (Hill, 1964); for the main stream of S-R theory as it is practiced today (also see below) has incorporated into its theoretical structure intervening variables which attempt to account for much of the cognitive and purposive commitments of the S-S group.

The "Mediated" S-R Model

As just indicated, the main current of S-R theory today is making a rapprochement with the concerns of the cognitive theorists. This should not be taken to mean that this has come about easily or necessarily of choice; rather it seems to have been spawned of necessity.

Nearly every theorist who has dealt with the problem of S-R or associational learning has assumed that the essential element in such learning is one of contiguity. This position assumes that if two elements, A and B, become associated with each other it is because they are experienced closely together in time. The difficulty with this view is that it is widely observed that one idea sometimes seems to lead to another without any evidence of contiguity between the two ideas in previous experience. The problem for the associationists, then, if they are to hold to contiguity as a basic principle of associative learning, is one of developing a way to describe or account for these apparently continguous associations. Such a device is provided by the concept of mediation. As typically used in the literature, mediating processes are those events which "...serve to bridge the gap between the stimulus or problems presented to an individual and the responses he makes...the major purpose of all mediational activity is...to provide for some indirect relation between the stimulative situation or problem and behavior." (Deese and Hulse, 1967, p. 427)

The principle of mediation asserts that associations sometimes come about between two elements, A and B, because they are both associated with a third element, C: the third element serves to bridge the gap between the two non-contiguous elements. (Instead of thinking in terms of mediating processes some theorists prefer the notion of mediating responses.) While such notions have been a part of almost all major learning theories in one form or another, for example, Guthrie's movement-stimulation and Miller and Dollard's response-produced drive stimuli, the increasing attention being given to such constructs, and their extension into the explanation of problem solving, concept learning and other relatively complicated learning-behaving processes, is having the effect of restructuring the focus and content of much of the learning literature.

Most thinking about mediational processes follows one of three models: mediation by chaining, mediation by stimulus equivalence, or mediation by response equivalents (Jenkins, 1963). In mediation by chaining the mediating term serves as an intervening link between the two terms which are to be associated; in mediation by stimulus equivalence the mediation serves to make two stimuli equivalent to one another; mediation by response equivalence does the same on the response side of the equation. The paradigms for these three mediation models are summarized in Table 3. The work of Spence (1960), Kendler

STAGE	CHAINING	STIMULUS EQUIVALENCE	RESPONSE EQUIVALENCE
Learn:	A – B	A – B	B – A
Then Learn:	B – C	C – B	B – C
Test For:	A – C	A – C	A – C

Table 3. Principal types of mediation paradigms (after Deese and Hulse, 1967, p. 316)

and Kendler (1962), Bourne and Restle (1959), and Goss (1961) is representative of these paradigms. Osgood (1957, 1964) has extended the concept considerably beyond these simple paradigms in an effort to make the basic S-R model applicable to language and perceptual phenomena. In relative terms Osgood is foremost amongst the S-R theorists to take a forthright stand against the psychology of the "empty organism."

The Information Processing Model

Within recent years an increasing number of psychologists have turned away from the S-R model as an adequate base for the explanation of human learning and behavior (Broadbent, 1958) (Miller, Gallenter and Pribram, 1960) (Deutsch, 1960) (Guilford, 1965), substituting in its place a theoretical position which draws upon a composite of 1) general systems theory (Von Bertalanffy, 1950, 1951) (Von Forester, 1951); 2) cybernetics and the development of servomechanisms (Ashby, 1960) (Wiener, 1954); and 3) information theory (Qualtler and Wulff, 1955) (Garner, 1962) (Attneave, 1959) (Travers, 1964). While the effects of Broadbent, Miller, Gallenter and Pribram, and the like are in the tradition of the S-S group in that they focus directly upon the processes occurring within the central nervous system, they are equally in the tradition of the scientific and technological flow of the moment.

Several concepts are central in this cybernetic or information processing or general systems approach.

1) Control and self-regulation through feedback. Cybernetics evolved during the Second World War and has had immense implications for the development of new kinds of machines, guidance systems, weaponry systems, etc. As a science, cybernetics is devoted to the study of control mechanisms and communication based on information feedback. The difference between a regulated and a self-regulating machine can be summarized in essentially one word: feedback. Regulated machines, once "turned on," perform their function until they are "turned off" or break: the energy alloted to them is utilized to perform the function for which they were constructed. Changes in the environment in which they function—unless such changes were anticipated by the machine's designer — simply do not enter into the machine's operation. In contrast, self regulating machine or servomechanisms—machines with feedback—*monitor* their own performance. They utilize some of the energy they receive or generate to control their own energy output. When action-in-progress is enhanced, it is said to come about through positive feedback. The most commonly used example of a self-regulating system is the thermostatically controlled room. The basic assumption of nearly all psychologists working in this area is that the

concepts of positive and negative feedback apply to the operation of the central nervous system.

2) The concept of systems. Broadly speaking, a system refers to a set of orderly and persisting inter-relations between parts of a whole. Such a system may be of any level of complexity, from a worldwide organization down, and it can include any possible set of variables which affect each other, whether physically affected or not. Thus the concept is as applicable to the self as an organized system as it is to a nation and as applicable to machines as it is to living organisms. Also, by definition, the boundaries of systems are arbitrary; there are systems, subsystems within systems, and subsystems within subsystems within systems, *all of which depend for their definition upon the parameters which one wishes to assign them.* In this connection, a distinction has been made between open and closed systems by Von Bertalanffy (1950) that is particularly useful in thinking about living systems in contrast to inanimate systems. As used by Von Bertalanffy, closed systems are usually found in the physical, inanimate world and are subject to the second law of thermodynamics (entropy) which says in effect that any closed system eventually reduces to a state of static equalibrium. Biological or open systems seem to disobey the closed system rule, though as Von Bertalanffy has pointed out, open systems by definition draw continuously upon the free energy of their environments.

3) The concept of process. At the heart of the concept is the idea that "...a given transaction produces different products according to when and where and how much and upon what that process is operating." (Frank, 1963, p. 15) Frank applies this concept to the conceptualization of the developmental (learning) process.

> If we are to pursue the study of processes of development, we must escape from the familiar assumption of linear relations and recognize that in organism-personalities, we are dealing with circular, reciprocal feedback, with non-linear relationships, in which the antecedent may initiate a response of much greater magnitude, not limited as in cause and effect or stimulus and response.
>
> So long as we are guided by the classic formulation of physical events as occurring through the transferring of energy in necessary and sufficient quantities to cause the observed effect, we are limited in our ability to conceptualize a process. This process operates not according to power engineering but according to communication engineering in which a message, such as a signal, a sign or symbol evokes in the

recipient a response with only a minimum of energy being transmitted. His response is a function of his present state or condition, patterned by his previous life experience, thus resembling a Markoff process." (p. 16-17)

4) The concept of information and information processing. Information theory had its beginnings in the fields of engineering and statistics, and consequently it is predominately a mathematical theory. It was originally meant to handle the measurement of information transmission in communications systems, such as telephone and radio, but psychologists have found the concepts of sufficient use that they have translated them into central nervous system and behavioral terms. The constructs central to information theory are sufficiently numerous and complex that their definition will not be attempted here. For those interested, Travers gives an excellent overview of information theory from the point of view of its applicability to the audiovisual field (Travers, 1964, Chapter 3). In that reference the reader will encounter such constructs as the "bit" or binary digit (the basic unit of information in the mathematical sense), alphabet, message, channel, channel capacity, code, ensemble, noise, and redundancy. The basic model of an information transmission system, as presented by Travers, appears as Figure 13.

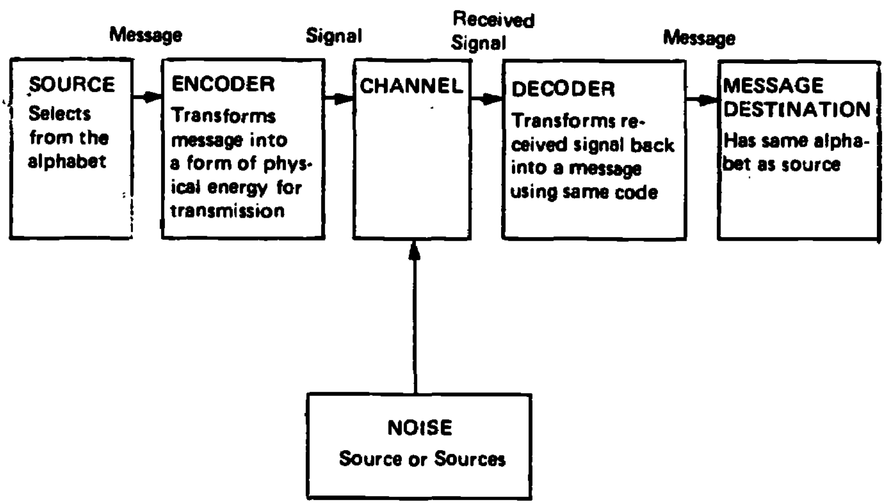


Figure 13. The basic elements within an information transmission system.

Several systems have been built upon these general principles in an effort to explain learning or the control of behavior. The better known of these are those developed by Miller, Gallanter, and Pribram (1960), Broadbent (1958), and Guilford (1965). The work of each will be reviewed briefly.

THE TOTE MODEL OF MILLER, GALLANTER, AND PRIBRAM. Miller, Gallanter and Pribram focus essentially on the problem of how the knowledge which people have constrains or determines what they do. In their book, *Plans and the Structure of Behavior* (1960), they argue for the development of a concept in the behavioral sciences called Plan, which they conceive to be "...any hierarchical process in the organism that controls the order in which a sequence of operations is to be performed." They view a Plan essentially as they view a program for a computer and refer frequently to the work of Newell, Shaw, and Simon (1960). They also developed the construct of Image and define it as "...all the accumulated, organized knowledge that the organism has about itself and its world." The central problem of the book is to describe the relations between images and plans.

In following this task they develop the concept of a TOTE (Test-Operate-Test-Exit) unit which operates as an interface between images and plans. Conceptually, as information enters the organism it is checked against the accumulated set of images that the individual has and the plan that is operational at the moment to determine if there is a fit between the newly arrived information, the plan and the cumulative store of information. If there is not a fit either the information store, the plan, or the environment is "operated" upon until there is a fit and the plan can proceed. A TOTE unit, as conceptualized by Miller,Gallanter, and Pribram, appears as Figure 14.

Throughout the book the organism is perceived as an information processing system and as such adds new dimensions to traditional psychological theory. By and large, the treatment of the topic given by

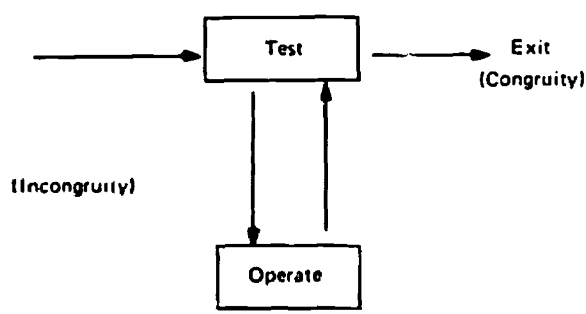


Figure 14. A schematic of the TOTE model

the authors is relatively general, and beyond the basic idea contributes little to the advancement of the field.

BROADBENT. By far the most extensive theoretical and conceptual treatment of the application of information theory to learning and behaving has been provided by Broadbent (1958). So that the reader may develop some feel for how a systematic treatment of this kind appears, the principles of Broadbent's system will be listed.

1. A nervous system acts to some extent as a single communication channel, so that it is meaningful to be regarded as having a limited capacity.

2. A selection operation is performed upon the input to this channel, the operation taking the form of selecting information from all sensory events having some feature in common.

3. The selection is not completely random, and probability of a particular class of events being selected is increased by certain properties of the events and certain states of the organism.

4. Properties of the events which increase the probabilities of the information, conveyed by them, passing the limited capacity channel include the following: physical intensity, time since the last information from that class of events entered the limited capacity channel, high frequency of sounds as opposed to low (in man) sounds as opposed to visual stimuli or touch as opposed to heat.

5. States of the organism which increase the probability of selection of classes of events are those normally described by animal psychologists as "drives." When an organism is in a drive state it is more likely to select those events which are usually described as primary reinforcements for that drive.

6. Given that two signals have been selected one after another, the conditional probability of the second given the detected occurrence of the first is stored within the nervous system in a long term (relatively slowly, decaying) store.

7. In accordance with Deutsch's postulates when an animal is in a drive state it will indulge in appetitive behavior until one of the temporarily high priority events occurs at its sense organs. Its behavior will then vary in such a way that it receives that ordered series of stimuli which, from account of past conditional probabilities, has the highest probability of terminating in the primary reinforcement for that drive.

8. Incoming information may be held in a temporary store at the stage previous to the limited capacity channel: it will then pass through the channel when the class of events to which it belongs is next selected. The maximum time of storage possible in this way is in the order of seconds.

9. To evade the limitations of short term storage it is possible for information to return to temporary storage after passage through the

limited capacity channel: this provides storage of unlimited time at the cost of reducing the capacity of the channel still further, possibly to zero. (Long term storage does not affect the capacity of the channel, but rather is the means of adjusting the internal coding to the probabilities of the external events; so that the limit of the channel is an informational one and not simply one of a number of simultaneous stimuli.

10. A shift of the selective process from one class of events to another takes a time which is not negligible compared with the minimum time spent on any one class.

Of these ten principles all but 9. and 10. are well founded empirically. A schematic representation of these principles in the form of an information flow diagram appears as Figure 15. Figure 16 represents Traver's modification of the Broadbent model (Travers, 1964).

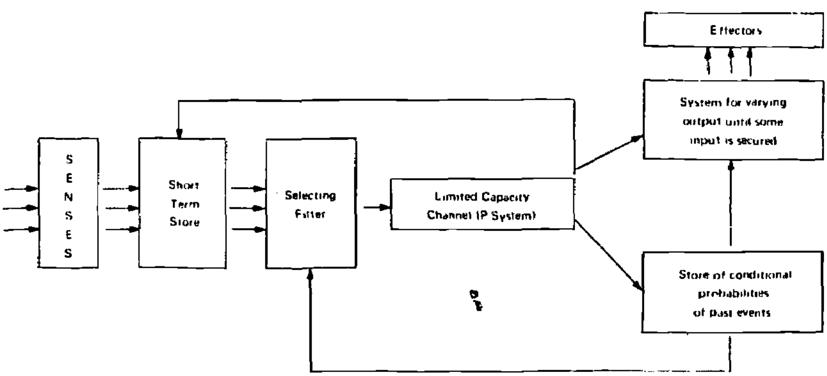
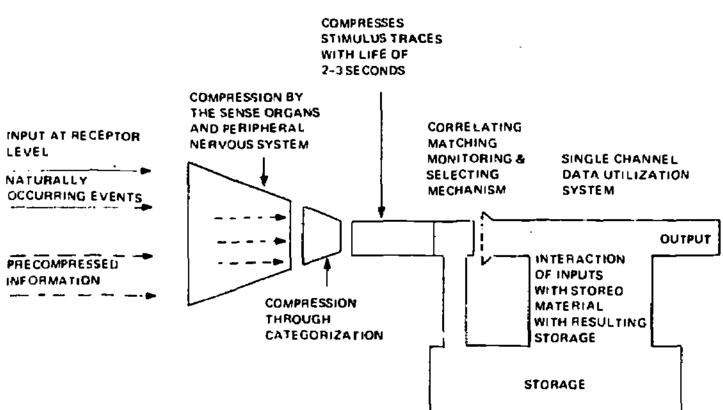


Figure 15. A tentative information-flow diagram for the human organism.



e 16. Traver's modification of Broadbent's information processing model.

GUILFORD. Recently (1965) Guilford has attempted to place his three dimensional model of intellect into a general systems or information theory frame of reference. By and large he makes the translation rather well and while little new is added to his model the information and flow diagram is relatively well worked out. As another instance of the kind of work that is going on in this area Guilford's flow diagram has been included as Figure 17.

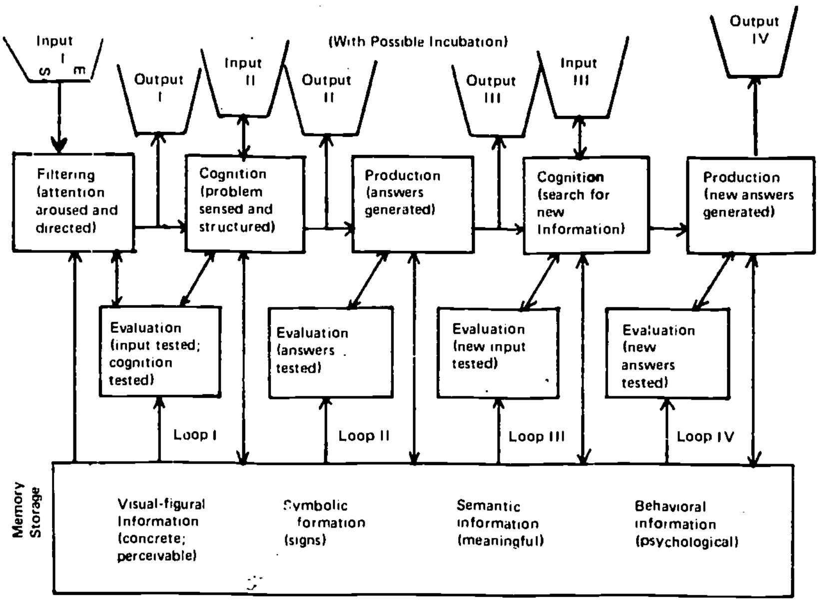


Figure 17. Guilford's schematic diagram of the flow of information in a somewhat typical instance of problem-solving, from input (from environment and from soma) to the output of accepted information.

What has been the contribution of this line of effort thus far? I think it possible to identify two major contributions: 1) it has triggered a line of theoretical and empirical activity of a highly sophisticated nature, exemplified by the work of Broadbent, Travers, and more recently, Smith and Smith (1966); and 2) it has begun to influence the way psychologists and neurophysiologists (Girard, 1960) view the relationship between brain and behavior. Specifically, it has forced theorists to move from viewing this relationship as a rather static to a dynamic one, and at the same time realizing that the dynamic model can be consistent with natural law and mathematical formulation. Also, as Cofer and Appley point out (1964), the movement generally has "... attacked the vitalist argument for discontinuity between animal and environment and with increasingly impressive demonstration has been narrowing the gap between the physical and biological universes of understanding" (p. 356). While it is too soon to predict with certainty the long range impact of this new movement within the field of psychology, it is likely that in the future it will assume an increasingly central position in all our thinking about man and his relationship to his environment.

Neurophysiology and the Chemistry of Learning

Along with the general hesitancy of psychologists to speculate about the nature of the learning processes, they have also been hesitant to speculate about the neurophysiological or the neurochemical basis of those processes. Within recent years sufficient progress has been made within these fields, however, for psychologists to find it difficult to continue to ignore the issues. Both limitations in length and focus of the present paper will not permit the discussion of these developments in detail. Two recent and ongoing lines of effort will be identified, however.

NEUROPHYSIOLOGY. Probably the best known effort to integrate recent neurophysiological information with psychological theory is that of Hebb's (1949). As Hebb defined the purpose of his book it was to present "...a theory of behavior that is based as far as possible on the physiology of the nervous system, and make sedulous attempt to find some community of neurological-psychological conception." (p. 1) Central in Hebb's theory was the notion of the "cell-assembly," a diffuse system of cells capable of acting as a closed-loop information system, delivering facilitation to other like systems and usually having a specific motor facilitation when strung together in series. A number of cell assemblies in action, labeled a "phase sequence," constitutes the basis for the thought process. Because Hebb dealt broadly with the issues of learning and behavior, and addressed himself seriously to the question of the relationship between experience and development, his contribution has had major impact upon the thinking of psychologists for the past two decades.

Much has occurred within the field of neurophysiology since the time Hebb made his original contribution, however, and Karl Pribram has made an effort to bring this information to the attention of psychologists and educators (1959, 1960, 1963, 1964). Chapters by Gerard and Livingston in the *Handbook of Physiology*, published by the American Physiological Society in 1960, also do much to translate recent neurophysiological data into a psychological frame of rerence. Woodburne's recent book, *The Neural Basis of Behavior* (1967); undertakes a similar task.

NEUROCHEMISTRY. In light of recent experimental work, no discussion of the process of learning would be complete without some reference to the work that has been done within recent years on the "chemistry of learning." A recent summary of this work by David Krech (1968) provides a simple to read digest. On the basis of Krech's review, some of the more striking results from this line of research include:

1) Confirmation of the two-stage memory storage theory;

2) Confirmation of the hypothesis that the synthesis of new brain proteins is crucial to the establishment of the long-term memory process;

3)Demonstration of the ability to either interfere with or facilitate both the long term and short term memory function, through either chemical or mechanical means;

4) Demonstration that by increasing the activity of the short term memory processes by electro-chemical means there is an increase in the performance of genetically dull animals to a point where the quality of their performance is beyond that of bright animals. There is a point, however, beyond which both bright and dull rats cannot improve performance;

5) Demonstration that there is an optimal dosage of drugs for the improvement of performance that is dependent upon individual experience and genetic factors;

6) Demonstration that drugs do not work in a monolithic manner on learning or memory but rather that some drugs act upon attentiveness, some on the ability to vary an animal's attack on a problem, some upon persistence, some upon immediate memory, and some on long-term memory. As Krech puts it, "Different drugs work differentially for different strains, different individuals, different intellectual tasks, and different learning components;

7) Demonstration that enriched experiences in the early life of animals gives rise to enlarged and proportionately heavier brain structure than when animals are detained under "deprived" experiential conditions (though not deprived nutritional conditions). In light of these results Krech restates his earlier summary as follows; "...to the extent this or that drug will improve the animal's learning ability will depend of course on what the drug does to the rat's brain chemistry, and what it does to the rat's brain chemistry will depend upon the status of the chemistry in the brain to begin with. And what the status of the brain's chemistry is to begin with reflects the rat's early psychological and educational environment." (p. 68)

In looking ahead, it may be possible, as Krech suggests, that "both the biochemists and the teachers of the future will combine their skills and insight for the educational and intellectual development of the child; Tommy needs a little bit more of an immediate memory stimulator: Jack could do with a chemical attention span stretcher: Rachel needs an anticholinesterase to slow down her mental processes." Whether and when this kind of prediction comes about, the students of learning and instruction must at least be cognizant of its possibility.

Supplement 4

An Overview of Positions Held with Respect to The Conditions of Learning

The conditions of learning involve the interplay between two major parameters: 1) instructional materials (curricula) and instructional procedures (methods). The present review is organized accordingly.

Instructional materials. Historically the nature of instructional materials available to the educator has paralleled rather closely the technological capabilities to develop them. Thus, with the advent of the printing press, instructional materials assumed the form of the printed book. With the extended development of technology the radio, television, the motion picture film and ever more elaborately "packaged" materials have become available.

In a recent review (1964) Woodring has pointed out that until the 1930's the majority of materials used in schools were prepared by single individuals, making it possible for example for a person like McGuffey to essentially determine how reading should be taught and what selections from literature children should read in the elementary schools for more than half a century. Similarly, the great majority of textbooks used in secondary schools were written by university professors, and as such the content of secondary school curricula for many years was essentially a simpler version of the history or science or literature taught in college. During the 1940's and early 50's elementary school textbooks began to be produced by committees, often composed of one or more academic scholars but also curriculum consultants or other professional educators and a design specialist from a publishing house. The result of this movement was that text books were relatively easily understood by children, were attractively made up, but were less closely related than previous texts to the world of scholarship.

Another shift in the content and development of educational materials occurred toward the end of the 1950's with the rise of Sputnik. Whereas the academic scholars and scientists had been relatively uninvolved in the content of elementary and secondary curricula for a number of years, new interest suddenly appeared and with the help of foundation and governmental support groups of distinguished physicists and mathematicians, working closely with educators and secondary teachers set out to overhaul the content of the public school curriculum. These advanced groups were followed by scholars from the fields of nistry, biology, languages, and the social sciences. As a consequence of these efforts elaborate new curricula have been developed, incorporating totally rewritten textbooks, the best possible of visual aids, supplementary reading materials and laboratory apparatus. On the surface at least scholarship once again has entered the public schools

What impact have the new curricula had on student learning? Unfortunately, at least in terms of the evidence now available (Ausubel, 1967), their impact upon students has not been as great as hoped. In fact there is little evidence that students going through these curricula are any better prepared as students in a discipline than those pursuing other curricula. Several reasons have been advanced for this relatively disappointing showing: 1) teachers are not able to handle the curricula, so as to permit students to benefit fully from the materials that they have access to, even though extensive institute programs have been established to help them do so, and 2) the new curricula deal only with content and it is probable that to make a real difference in the learning of children the *methods* by which the content is presented also have to be improved. Thus even though the new curricula provide well organized sequences of learning experiences, and the emphasis throughout it on problem solving rather than on memory of facts, the curriculum in and of itself is not sufficient to guarantee learning. Students must interact with a curriculum, and the methods teachers employ to bring this about apparently are critical to the effectiveness of that interaction.

The result of five years' work with the new curricula suggests that efforts of similar magnitude must be undertaken with respect to the *methods of instruction* if real progress in learning is to take place. Only when advances in methods are linked to the advances in curriculum can the power inherent in the new curricular efforts be realized.

Before leaving this brief review of instructional materials reference should be made to Bruner's concept of "optimal structure" with respect to a body of knowledge (1965). Bruner's concept of structure relates to the idea that a body of knowledge can be organized in a variety of ways and at a variety of levels of complexity and still maintain its identity as a body of knowledge; the merit of a structure depends upon its power for *simplified information*, for *generating new propositions*, and for increasing the *manipulability of a body of knowledge*. It is Bruner's contention that every discipline can be so structured and that in order to teach a subject area effectively such a structure must be generated, though the level of concepts used in the structuring depends upon the status and characteristics and the learner who is interacting with it. Essentially the new curricula represent such efforts, and while they are undoubtedly desirable they are not, as indicated previously, sufficient in and of themselves to bring about effective mastery of a given subject area.

Instructional procedures. Generally speaking, the behavioral sciences have more to say about instructional procedures or methods than they have about instructional materials; the province of instructional materials has always been that of the discipline or curriculum specialist while that of procedures has been that of the educator and the psychologist. Five lines of work can be identified within these two disciplines that has contributed to our understanding of instructional methodology: 1) the work of educators *per se*, 2) the work of personality theorists and ego psychologists, 3) the work of educational and/or learning psychologists, 4) the work of training psychologists, and 5) the work of the cyberneticists. Obviously, these do not represent independent lines of work, and the labels suggested are not at all exact in their meaning, but they do serve a generally useful purpose in ordering the field. The review that follows is organized around these topic headings.

EDUCATORS. Practicing educators and those writing textbooks which deal with the principles and practices of education have developed an enormous array of prescriptions that are intended as guides in establishing the conditions of instruction. Generally speaking these are drawn together from all possible sources, represent some apparent consensus, and are set forth in relatively broad, general terms. The plan of textbooks of a generation ago, for example Risk (1941), was to outline a set of learner outcomes, offer a list of principles to be applied in developing these outcomes, and suggest specific steps to be followed in the teaching process itself. The list of principles Risk offered for guiding the memorization process, "or governing drill," included the following:

(1) Be sure the exact association is known before drilling. Do not guess. Make prompt accurate responses. Speed is not important except in certain computations involving skill and in expressing results.

(2) Concentrate. Attention should be upon particular response to the stimulus. Avoid interfering associations that may easily intervene between stimulus and response.

(3) Learn under pressure. Where speed and expression is desired, compete with own or class record, or known standard.

(4) Drill periods should be short and distributed over a considerable period of time.

(5) Practice the correct method of recall with the particular associations in the way they are to be used.

(6) Begin drills promptly and aggressively. This facilitates concentration and heightens the effect of correct response in fixing the association.

(7) Apply associations in real situations whenever possible and practicable.

Risk goes on to outline the steps to be followed in the teaching process as:

(1) Preparing the pupils by:
a) Helping pupils to get right concepts of associations to be memorized by questioning, telling, illustrating, etc., with reference to (1) past experience related to its present association, and (2) observing facts, principles, relationships, etc., if necessary or helpful.

b) Setting forth a definite association to be learned;

c) Testing and and correcting pupils to assure mastery of correct associations to be memorized.

(2) Directing drill. The direction of drill usually needs to be very carefully planned because drill is tiresome, and often boresome. Much valuable time can be wasted through lack of planning. (p. 201)

In modern textbooks, for example Klausmeier and Goodwin (1966), much the same plan is adopted: categories of learner outcomes are listed and broad, general prescriptions or principles are offered as guides to a teacher in bringing them about. Klausmeier and Goodwin list the following principles in their "Model for Teaching Factual Information":

1) Organize material for the individual.
2) Use advance organizers.
3) Provide for proper sequencing of material.
4) Arrange for appropriate practice.
5) Encourage independent evaluation.

The principles they list in their "Model for Aiding Concept Learning" include:

1) Emphasize the attributes of the concept.
2) Establish correct language for the concept.
3) Provide for proper sequencing of instances.
4) Encourage and guide student discovery.
5) Provide for applications of the concept.
6) Encourage independent evaluation.

While the Klausmeier and Goodwin list of principles represents an obvious advancement in the sophistication and probable power of instructional methods compared to those listed by Risk both approaches suffer a major limitation, namely, they do not specify instructional practices in terms of concrete teaching behaviors. What, for example, in concrete behavioral terms, does a teacher do when she provides advanced organizers? Or, what are the specific overt behavioral moves required of a teacher in arranging for appropriate practice or encouraging independent evaluation? Ultimately the conditions of instruction have to be defined in terms of concrete teaching behaviors, and the approach traditionally taken by educators and the writers of educational textbooks has not moved to that level of detail.

Two efforts have been directed toward filling in this gap in our knowledge of educational practice. The first has a rather long history and can be labeled for convenience as "studies of teacher characteristics." The second approach is more recent in its history and can be labeled as "studies of classroom interaction." The study of teacher characteristics has its best known origins in the work of Anderson (1943) on dominative and integrative behavior of teachers in the classroom and in the work of Lewin and Lippitt and White in the study of classroom leadership patterns (1939). This general line of work reached its climax in the work of Ryans (1960) on the characteristics of teachers. In this work Ryans was able to identify such patterns of teaching behavior as understanding, friendly; aloof or restricted; responsible, business like, etc. While it is now generally agreed that this line of work has had relatively limited payoff for education (Biddle and Ellena, 1964) it has been a constructive force in getting educators to move from generalized prescriptions of teaching principles or practices to a concern for the behaviors which are actually reflected in classroom procedures.

Starting with the work of Medley and Mitzel (1958), Hughes (1959), Flanders (1960) and Smith (1960), and continuing with the work of Bellack (1963, 1965), Aschner and Gallagher (1963) Taba (1964) and others, the study of the overt behavior of teachers in the classroom has grown at a rapid pace. While this has been an extremely active research area, most of the effort thus far has been directed toward the development of a methodology which permits the description of teaching behavior and its relatively simple application to descriptive issues. As yet there has been little attempt to systematically relate classes of teaching behavior to classes of learner outcomes (Medley and Mitzel, 1963; Gage, 1966). More critical still, perhaps, is the relative lack of sophistication that has been brought to both the conceptualization and the methodology for measuring teaching behavior (Schalock, 1967). Generally speaking the observation systems that have been developed do not tie closely to that which is known about cognitive development and the teaching-learning process; they do not tie teaching behavior to the contextual variables within which it occurred, for example learner behavior and setting variables, and there has been little effort to make the systems applicable across a wide range of ages and settings so that comparable data can be obtained by investigators working in widely differing projects. Apart from these apparent limitations, however, the move to study teaching behavior in context represents a constructive and sorely needed effort to bridge the gap in our knowledge of the educative process. Much remains to be done, but at least an awareness of the problem now exists and a growing number of educational researchers are committed to its pursuit.

Personality Theorists and/or "Ego" Psychologists.

By and large personality theorists and ego psychologists tend to offer broad humanistic, emotionally tinged prescriptions for use in the guidance of instruction rather than specific lists of principles derived from experimental work. Excellent examples of such prescriptions can be found in the Association for Curriculum Supervision & Development's yearbook *Perceiving, Behaving, Becoming* (1962). Writing in the yearbook, Kelley speaks to the kind of experiences a child needs to develop "a fully functioning self."

> For the development of a fully functioning self, a person needs to have opportunity to live the life good to live. This life, or his world, needs to be populated by people whom he can view as facilitating. It is almost entirely a matter of people, not things....The life good to live is a cooperative one. No child is too young to sense whether or not he lives in a cooperative relation with the people around him. The reason that cooperation is so important is that the cooperative atmosphere is one of involvement. The growing self must feel that it is involved, that it is really part of what is going on, that in some degree it is helping shape its own destiny, together with the destiny of all. Perhaps there is no one quality more important for the developing self than this feeling of involvement in what is taking place. This is what gives a person a "reason to be." The lack of consultation and involvement is the cause of the continuing war between parents and their children, between teachers and learners, between teachers and administrators, employers and employees, ad infinitum. When the person is a part of something, then he becomes responsible. (Kelley, 1962, pp. 16-17)

In the same vein Maslow states that

> ...the main path to health and self-fulfillment is via basic need gratification rather than via frustration. This contrasts with the suppressive regime, the mistrust, the control, the policing that is necessarily implied by basic evil in the human depths.

Intra-uterine life is completely gratifying and nonfrustrating and it is now generally accepted that the first year or so of life also had better be primarily gratifying and nonfrustrating. Asceticism, self-denial, deliberate rejection of the demands of the organism, at least in the West, tend to produce a diminished, stunted or crippled organism, and even in the East, bring self-actualization to very few exceptionally strong individuals.

In the normal development of the normal child, it is now known that most of the time, if he is given a really free choice, he will choose what is good for his growth. This he does because it tastes good, feels good, gives pleasure or delight. This implies that he "knows" better than anyone else what is good for him. A permissive regime means not that adults gratify his needs directly, but make it possible for him to gratify his needs and to make his own choices, i.e., let him be. It is necessary, in order for children to grow well, that adults have enough trust in them and in the natural processes of growth, i.e., not interfere too much, not make them grow, or force them into predetermined designs, but rather let them grow and help them grow in a Taoistic rather than an authoritarian way.

But we know also that the complete absence of frustration is dangerous. To be strong, a person must acquire frustration-tolerance, the ability to perceive physical reality as essentially indifferent to human wishes, the ability to love others and to enjoy their need-gratification as well as one's own (not to use other people only as means). The child with a good basis of safety, love and respect-need-gratification is able to profit from nicely graded frustrations and become stronger thereby. If they are more than he can bear, if they overwhelm him, we call them traumatic, and consider them dangerous rather than profitable. (Maslow, 1962, p. 39)

Still another example is offered by Combs:

People discover their self concepts from the kinds of experiences they have had with life; not from telling, but from experience. People develop feelings that they are liked, wanted, acceptable and able from having been liked, wanted, accepted and from having been successful. One learns that he is these things, not from being told so, but only through the experience

> of being treated as though he were so. Here is the key to what must be done to produce more adequate people. To produce a positive self, it is necessary to provide experiences that teach individuals they are positive people. (1962, p. 53)

> Identification, like the self concept, is learned. It is the product of the individual's experience and an outgrowth of the essentially positive view of self we have already described. One learns to identify with others, depending upon the nature of his contacts with the important people in his life. As people are friendly and helpful, it is easy and natural to extend one's self to include them or to feel at one with them. As people are harmful and rejecting, on the other hand, one's need to protect himself produces an organization from which such people must be excluded. It is a natural reaction to build walls against those who hurt and humiliate us. On the other hand, it is possible to lower defenses when we can be sure of the friendly behavior of others. (1962, p. 55).

While such general prescriptions have a ring of wisdom to them, and in fact generate considerable enthusiasm on the part of educators, they are a long way from the level of specificity required to design specific instructional experiences for specific children under specific learning outcomes.

Historically the ego psychologists have assumed a role similar to that of the personality theorists cited above in that their prescriptions have been broad and appealing at the emotional level (Rapaport, 1957) (Alexander and Selesnick, 1966), but recently there has been a major effort to translate some of the broad notions developed by this group into principles applicable to an instructional setting (Hollister and Bower, 1966) (White, 1963). Also there is a corresponding effort to tie these concepts to programs of research (Bower, 1966). One example from Bower will illustrate.

> In order for a child to learn processes of ego differentiation, a number of interrelated ingredients are required. Among these are: (a) language, (b) an opportunity to contact, sense, and experience a wide variety of things and people, and (c), most important, bridges or mediational agents to help the child fit symbols and experiences together comfortably and functionally...

> At present, experimental curriculum programs—especially with kindergarten and preschool children—are attempting to

> find ways of reversing ego-diffusion processes in lower-class children. In one such preschool program the teacher, when speaking to a child, will face the child at eye level and enunciate with full mouth and lip movement so that the words are clearly and distinctly differentiated from others. Such programs also include games in which symbols and objects are linked in various contexts or in which unfamiliar and familiar objects are placed in a box, identified and differentiated by touch, sight, or description...
>
> Games are extremely helpful in encouraging language usage and the differentiation of objects and words. For example, a child may verbalize more spontaneously via a toy telephone in a toy booth than in a face-to-face situation. The results can be taped and fed back as part of the game. In addition; preschool and school programs seeking to enhance ego-differentiation processes may utilize exercises in figure-ground discrimination, training in the differentiation and identification of sounds and manipulation of new objects, pictures, and words. Some teachers use photographs, pictures, or silhouettes to assist the child in differentiating himself... (1966, pp. 115-116)

In time, if this line of attack continues, ego psychology stands to become as dynamic a force in the field of education generally as it has been in the fields of therapy and preschool education.

EDUCATIONAL AND/OR LEARNING PSYCHOLOGISTS. Much like educators psychologists also have tended to compile and organize the learning literature from the point of view of formulating a list of principles to be used in guiding the instructional process. Typically the listing draws from the full range of literature on the psychology of learning, and includes such concepts or principles as using learning sets and advance organizers, making initial learning meaningful, reinforce or provide satisfying consequences to correct responses, distribute practice and review, provide for immediate application of that which has been learned, provide for sequential cumulative learning, help students set and attain realistic goals, avoid high stress and disorganization, increase the distinctiveness of the elements of a task, build upon response availability in guiding the learning process (Underwood, 1959; Gagne, 1962; McGooch and Irion, 1952; and Klausmeier and Goodwin, 1966).

Unfortunately, as indicated elsewhere in the paper, the work of educational and learning psychologists has had little immediate impact upon educational practice. Glaser (1964) outlines why he thinks this has been the case:

> Advocates of this approach profess to summarize principles and rules of thumb for managing the learning process which are derived primarily from laboratory learning research. The principles listed ("and principle" is usually put in quotes) are stated as guides to practices which must be validated in real training in an educational situation. This statement is followed by the cautions required because the differences between laboratory research and real-life education, e.g., type of subject, duration of learning, complexity of the task, and so on. Following this is a statement of the necessity for programmatic research to bridge the gap between the science of learning and the management of training and education. (p. 168)

While these comments are somewhat caustic and a bit overdrawn they do in essence represent the circumstances that exist with respect to the contribution of the traditional learning psychologists with reference to specification of the conditions of instruction in a real-life setting. Failure of the learning psychologists to tie their work systematically to classes of learner outcomes and to seriously tackle the question of learning processes has already been discussed.

Three notable exceptions to these rather sweeping generalizations are 1) the recently developed programs in behavioral modification (Haring, 1967; Patterson, 1965, 1966, 1967; Bijou and Bair, 1965), 2) programmed instruction (Lumsdaine and Glaser, 1960; Lumsdaine, 1961, 1964; Skinner, 1954, 1958), and 3) the translation of the learning literature by Gagne into instructional terms (1965). Historically the first two developments have grown largely from Skinner's "operant conditioning" methodology and represent healthy if somewhat boisterous newcomers to the educational scene. Both emphasize active participation by learners in the process of learning, immediate confirmation of the appropriateness or inappropriateness of response, and individually paced progression toward learning outcomes. Central to both lines of effort is the concept of reinforcement or reward. Skinner describes the concept as follows:

> We make a reinforcing event contingent on behavior when, for example, we design a piece of equipment in which a hungry rat or monkey or chimpanzee may press a lever and immediately obtain a bit of food. Such a piece of equipment gives us a powerful control over behavior. By scheduling reinforcements, we may maintain the behavior of pressing the lever in any given strength for long periods of time. By reinforcing special kinds of response to the lever - for example, very light or very

heavy presses or those made with one hand or the other—we "shape" different forms of topographies of behavior. By reinforcing only when particular stimuli or classes of stimuli are present, we bring the behavior under the control of the environment. (1963, p. 52)

In developing programs of behavioral modification the task is to find reinforcers that are effective with different classes of children and to train teachers in the application of reinforcers on specified schedules. All kinds of reinforcers have been found to be effective, ranging from candy and social approval to tokens, and they have been found to be effective with normal, retarded and mentally disturbed children from pre-school to college age. Thus far behavioral modification techniques have been applied primarily to the modification of social behavior though it has been found to have utility in facilitating cognitive development as well (Haring, 1967).

In contrast to the application of behavioral modification techniques programmed learning procedures have been applied specifically to the development of cognitive abilities. While resting upon the same general principles as behavioral modification two additional concepts are critical to programmed instruction: 1) the idea that any educational subject can be regarded as an accumulative repertoire of behavior which can be analyzed logically and behaviorally into a number of small "steps" representing increments of successive approximation to final mastery, and 2) the idea that an optimal sequence of steps can be developed and refined on the basis of detailed records of responses made by typical students to a preliminary version of an instructional program (Lumsdaine, 1964, p. 383). Operationally:

> *An instructional program is a vehicle which generates an essentially reproducible sequence of instructional events and accepts responsibility for efficiently accomplishing a specified change from a given range of* **initial competencies or** *behavioral tendencies to a specified terminal range of* **competencies or** *behavioral tendencies.* Such a defintion has a minimum of restrictive connotations and can encompass most of the forms of programs that have been proposed. It makes no particular theoretical presuppositions and does not even require individual progress or overt response by the learner as part of the definition (though these characteristics may turn out to be theoretically or experimentally deducible as consequences of the general definition). Thus, a variety of program types and styles is admitted, which may differ in terms of using larger or smaller steps, varying amounts and kinds of student response,

and any number of forms or combinations of "linear" paths or types of contingent alternative or "branching" sequences. However, it is evident that, in some sense at least, the definition implies a programmed sequence of learner behavior, not merely a reproducible set of stimulus materials.

A program is presequenced and implies a presentation to the student, not just a source of material to which the student may expose himself. A program thus has a beginning and an end; to borrow a phrase from computer programming, it has a start order and stop order. The crucial aspect of this conception of programming is expressed by the "programmer's credo" that if the student doesn't learn, the programmer hasn't taught. This is the fundamental acceptance of responsibility for the management of learning—for trying to see to it that the student does learn and taking the blame for his failures. In an ideal program, the "stop order" occurs only when the student shows either that he has mastered the capabilities which are the program's objectives or that he is basically incapable of doing so (Lumsdaine, 1964, p. 384-85).

Given this definition of instructional programming it is clear that the concept extends considerably beyond that which was initially thought of when people mentioned programmed learning. Initially programmed learning was associated inseparably with "teaching machines," and thus conceived of as involving relatively limited paper and pencil programs. Under Lumsdaine's definition limitations of this kind do not apply.

Gagne's translation of the principles derived from the learning laboratory into concrete instructional terms is the third exception to the general conclusion that learning psychologists have contributed little to on-line instructional practices. In an exceptionally cogent book (Gagne, 1965) has 1) outlined a taxonomy of learner outcomes that reflects the classes of outcomes found typically to be of concern to the learning psychologist and 2) summarized both the conditions within the learner (prerequisite conditions) and the conditions within the learning situation (instructional conditions) that are known to be essential to the development of these outcomes. While space will not permit a detailed review of Gagne's work, the following illustration provides a sample of the clarity and detail that are there. The sample centers only on the development of principles.

Conditions Within the Learner. The prerequisite for acquiring the chains of concepts that constitute principles is knowing the concepts. *Birds fly south in the winter* is easily learned as a principle when the learner has already learned all four concepts involved in it. There is, of course, a kind of "partial" learning of a principle that may result when the individual knows only some of the component concepts. Should a learner know all the concepts except *south*, it is apparent that some kind of principle could still be learned, but it would be an inadequate one.

As previously emphasized, knowing the concepts means being able to identify any members of the class they name. It is only when such prerequisite concepts have been mastered that a principle can be learned with full adequacy. Otherwise, there is the danger that the conceptual chain, or some parts of it, will become merely a verbal chain, without the full meaning that inheres in a well-established principle. It is unfortunately true that inadequate principles can be learned. It is a challenge for instruction to avoid these, and it is a challenge for measurement techniques to distinguish them from adequate ones.

Conditions in the Learning Situation. The major external conditions of principle learning are embodied in *verbal instructions*. The example of instructions used with *round things roll* will be useful to recall here.

1. The conditions of principle learning often begin with a statement of the general nature of the *performance to be expected when learning is complete*. In the previous example, the instructor says, "I want you to answer the question. What kinds of things roll?" Why does he say that? Isn't he simply stating the principle, giving it away, so to speak? The main reason for making such a statement, which the learner "holds in mind" during learning, appears to be this: It provides the learner with a means for obtaining immediate reinforcement when he has reached the terminal act. Having this statement for a model, he will be able to know when he has finished learning, and in many cases, when he has acquired the correct principle. Since principles may be long chains, the learner may need to have a conveniently retained reference to tell him when the end is reached. The instructor, though, cannot be said to be "telling the principle." He doesn't state the principle itself, but only the kind of performance that will demonstrate the attainment of the principle.

2. Verbal instructions continue by *invoking recall of the component concepts*. The instructor says; "You remember what *roll* means .... You remember what *round* means." In many cases, the recall of these concepts is stimulated entirely by verbal means. In others (as in the example previously given) the class of stimuli that represent the concept may also be shown; the student may be asked to recall the *roll* event by identifying one, and a *round* thing by picking one out. Pictures, of course, may be used as well.

3. Verbal cues are next given for the principle as a whole. In our simple example, the verbal statement "Round things roll" accomplishes this purpose. However, it should be noted that these verbal cues to the principle need not be an exact verbalization of the entire principle; they are in this case only because the principle is such a short one. If the principle were one from elementary geometry like "An angle is formed by the intersection of two rays," the verbal cues may be contained in such statements as "Here are two rays. They intersect. We have an angle." Such statements do not correspond exactly to an acceptable verbal definition. Yet they function as well or better in providing verbal cues to stimulate the learning of the principle.

4. Finally, a verbal question asks the student to demonstrate the principle. The instructor says, "Show me." The exact form is not of great importance as long as it truly requires the student to demonstrate the principle in its full sense. Added to this may be the requirement of asking the student to state the principle verbally, as when the instructor asks, "What kinds of things roll?" But note particularly that such verbal statement is not essential to the learning of the principle, nor does it prove the student has learned the principle. Then why is it done? Probably for a very practical reason: the instructor wants the student to be able to talk about the principle later on, and so he teaches him the right words to say. This is undoubtedly useful, but it is important to note that this kind of verbal chaining ("learning the definition") is an unessential part of principle learning itself.

The Instructional Sequence. The conditions for learning principles that are in the situation, then are largely incorporated in an *instructional sequence*. Perhaps it will be worthwhile here to recapitulate that sequence (cf. Gagne, 1963a), since it may be considered to represent the requirements for instruction of principles whether practiced by a teacher, a film, or a textbook:

> *Step 1:* Inform the learner about the form of the performance to be expected when learning is completed.
>
> *Step 2:* Question the learner in a way that requires the reinstatement (recall) of the previously learned concepts that make up the principle.
>
> *Step 3:* Use verbal statements (cues) that will lead the learner to put the principle together, as a chain of concepts, in the proper order.
>
> *Step 4:* By means of a question, ask the learner to "demonstrate" one or more concrete instances of the principle.
>
> *Step 5* (Optional, but useful for later instruction): By a suitable question, require the learner to make a verbal statement of the principle. (Gagne, 1965, pp. 146-149)

While Gagne has done a remarkable job in translating much of the traditional literature on learning into a form which permits it to be used in instruction, his work suffers two limitations: 1) his taxonomy of outcomes is relatively limited in scope, and 2) he does not tie the "conditions of learning that are external to the learner," i.e., the conditions of instruction, in any absolute way to concrete teaching acts, though the examples he uses often involve concrete instances of behavior. Since the implications of both limitations have been spoken to previously, further comment about them is unnecessary. Even with these limitations, Gagne's work represents one of the major contributions to the educational psychological literature of the past decade and needs to be incorporated within any serious effort to conceptualize the nature of the instructional process.

TRAINING PSYCHOLOGISTS. As mentioned earlier, the term "training psychologists" refers to a rather large group of scientists working on problems of education and training within the context of the military and industry. While the work of this group has been relatively unknown to educators until the past few years their contribution represents one of the major research and development thrusts within education within the past 15 years. In large part this has come about through their constant confrontation with the responsibility of developing effective instructional programs for tasks of a highly complex "real-life" nature. In first approaching the development of such instructional programs they attempted to apply the principles derived from the learning laboratory. These in and of themselves proved to be inadequate to the task (Gagne; 1962). After considerable struggle two concepts emerged that provided the means by which to do the job that they were required to do, namely, the concept of task analysis and task sequencing. In combination these two concepts require the following steps:

1. The general job to be performed has to be analyzed into the complex of tasks that are required to perform it;

2. Once the tasks to be performed have been identified the specific task or tasks to be learned have to be analyzed into their component or subordinate tasks or skills or knowledges;

3. The complex of tasks to be learned, and the complex of prerequisite skills or abilities to be learned, need to be sequenced or ordered into an hierarchical sequence so that the successful achievement of first order tasks is accomplished before one moves to second order tasks, etc.

The entire procedure assumes that the task outcome or objective will be stated in behavioral terms so that one can design instructional programs that lead to it and one can know when the desired objective has been obtained. The similarity between the concepts outlined here and those central to programmed instruction are evident.

Another major contribution of the training psychologists has been the development and use of "simulation" procedures (Lumsdaine, 1960) (Gagne, 1963). For the mastery of complex, sequential learning tasks the concept of dynamic simulation as a training aid has been found to be extremely useful—if not essential—and as a result the use of simulation has spread throughout military and industrial training programs. It has also been applied to teacher education (Kersh, 1961) (Twelker, 1967) and to public school education in the form of teaching games (Twelker, 1967). As yet the specific role which simulation plays in the development of complex learning tasks has not been well defined, but sufficient work has been done with the methodology to know that in the future it will hold a central place in the educator's repertoire of instructional procedures.

Although the training psychologists have made several major contributions to educational practice they generally have been unable to integrate the contribution of the traditional laboratory learning psychologists with that of their own. In fact as late as 1964 Glaser was led to say that the experiences of the training psychologists "...lead to the conclusion that a promising approach to research and development in instructional technology is a synthesis of the concepts of task analysis and task sequencing, on the one hand, and instructional variables for guiding learners response on the other." (1964, p. 175). This is a distressing statement for it highlights the fact that while the procedures of task analysis and task sequencing have been developed to a rather high degree by the training group *the application of instructional procedures to the development of the outcomes so identified is still relatively* *primitive* (Melton, 1963). This in no way detracts from the contribution of this group, for surely any attempt to conceptualize the instructional process will have to incorporate the results of their work, but it does serve as warning that in order to develop maximally effective instruction considerably more must be learned of the instructional process itself.

THE CYBERNETICISTS. In light of the relatively recent evolution of that which has been called the cybernetic or systems approach to learning, the relatively few psychologists engaged in this class of activity, and its close alignment with the approach of the training psychologists, it is questionable whether a separate section in the review for this approach is justifiable. In view of the long range potential of the approach, however, and the recent appearance of Smith and Smith's *Cybernetic Principles of Learning and Educational Design* (1966), a brief review has been included.

In line with earlier discussions of the cybernetic or systems point of view the critical feature in learning to this group of psychologists is the concept of information feedback (in contrast to reward or reinforcement); learning or adaptation of behavior to the situation with which an organism is interacting is totally dependent upon it. In this view the individual is seen as

> ...a feedback system which generates its own activities in order to detect and control specific stimulus characteristics of the environment. In keeping with this point of view, cybernetic research analyzes the intrinsic mechanisms by means of which control is established and maintained - that is the closed-loop sensory-feedback mechanisms that define the interactions between the individual and his environment. In contrast, conventional learning research conducts open-loop analysis of the relationships between extrinsic events — stimuli and reinforcements—and observed responses. . Whereas conventional learning psychology proposes that learning is defined by the occurrence of external events in appropriate temporal relationships, cybernetic theory proposes that learning as well as other aspects of behavioral organization are determined by the nature of the feedback-control processes available to the behaving individual. (Smith and Smith, 1966, v. ii)

Beyond the work of the training psychologists, and the work of Smith and Smith on the effects of delayed, space-displaced and perturbed sensory feedback on selective aspects of performance and learning, little other systematic research using the cybernetic model has been pursued. Since the results of these research efforts have been particularly striking, for example, no effective learning occurs under conditions of delayed feedback and feedback delayed by small fractions of a second is seriously detrimental to sustained performance, and the focus of the research has been upon complex human learning in meaningful educational settings, there is some justification in alerting the reader to the work and insisting that an overall framework describing the conditions of learning take cognizance of the results coming from it.

Learner Variables and the Instructional Technologist

James H. Beaird

Focus

This paper is concerned with the multitude of ways in which individuals differ and with the problem of designing instructional materials and/or systems in such a way that they are appropriate for learners who possess varying patterns of characteristics. Several issues require consideration in the development of instructional systems. One of the least attended to concerns has been that of adapting instruction to the individuality of learners.

An initial focus of this paper is on the issue of whether or not adaptation of instruction to individuality is in fact necessary. Positions relative to this issue are dependent upon the way in which various groups look at the major problems facing education today. Approaching the problem from the point of view of the educational psychologist, one would be inclined to agree that greater attention should be given to the adaptation of instructional sequences to particular pattern of abilities characteristic of a given learner. If, on the other hand, one used the problems of education from a broader prospective, e.g.; that of a national economist or of a civil rights protagonist, a different position might be taken. A second focus of the paper is concerned with alternative strategies for handling individuality within an educational system. Five such alternatives are discussed.

One of the alternatives considered is that of adapting specific sequenced instruction for each specific learner. While such adaptation might be a worthy goal for the instructional technologist the position is taken that sophisticated adaptation of this type is extremely costly and may in fact be unnecessary.

At one point in the paper what might be termed as a golden rule is presented, to wit, "know thy audience". The suggestion of course is that greater attention by the instructional technologist might be given to the characteristics of individuals within the audience. With knowledge of these characteristics the suggestion is made that significantly large clusters of individuals may be identified who have similar characteristics. It is necessary that the instructional technologist prepare himself in such a way that he becomes a practitioner capable of utilizing the contributions of all the behavioral sciences in his world of work.

Mark Twain is often quoted as saying that "everybody talks about the weather but no one does anything about it." His observation was only partially true, of course, since although we do nothing about the causes of weather, we certainly engage in a lot of adaptive behavior as a result of it. The topic of this paper implies that it will be concerned with the utilization of information about individual differences or learner variables. To wear the teeth off of Twain's old saw, everybody talks about individual differences but nobody does very much about them.

Again the implication is that we are not here concerned with the modification of individual differences; that has been the topic of Schalock's paper. Instead our concern becomes that of adapting instructional design to individual differences. Modification of instructional strategies or development of a particular type of media are forms of adaptation to individual differences. It is true that we have spent, as educators, a great deal of time and effort talking about provisions for individual differences in our instructional programs. Unfortunately, woefully little active adaptation to individual differences has been made in instructional media. While the classroom teacher, the administrator, or indeed the instructional technologist might take issue with such a broad statement, the fact remains that, with rare exceptions, the adaptations made to individual differences have been of an administrative type rather than an organically related variation of instructional material or strategy.

Administratively, some schools have developed separate tracks for the bright, average, or slow learner. However, seldom does the actual instruction vary from one track to another. Instead the tracks are differentiated in terms of amount of content covered rather than the nature of the content. While this type of adaptation to individual differences is helpful and in fact probably superior to no adaptation at all, it is unlikely that it will, in the long run, prove to be most fruitful.

The most fruitful approach and the one that Cronbach (1967) terms the most "psychologically interesting" approach is that of modifying the instructional setting such that it is adaptive to salient and meaningful psychological differences in individuals. While the latter course is not an easy one to negotiate, increased attention to such alternatives by instructional technologists can significantly contribute to successful adaptations to individuality.

It is not my purpose in this paper to develop a long compendium of characteristics on which humans differ. Instead I will attempt (1) to cover a few of the areas in which individual differences have been shown to make a difference in learning situations, (2) to describe some of the recent research that has been conducted in each, and (hopefully) (3) to suggest strategies instructional technologists may want to employ to account for individual differences known to exist. In many cases, the research evidence is limited to laboratory studies of learning and will require extrapolation to actual learning situations. In other cases, although these are few, the research is focused directly on specific adaptations of instructional materials to account for individual differences of learners.

Is Adaptation to Individual Differences Necessary?

Most of us are products of educational programs in which attention to individual differences was not very central in the scheme of things. That we are engaged in the activities we are today is evidence that learners can survive such programs with little apparent forfeiture of productivity. Few would agree that today's learners are having their instructional programs form-fit to their unique patterns of capabilities. It is obvious that educational programs can persist without attention to individual differences and that certain groups of learners will profit, some even somewhat optimally. The problem is that today's society is not what it was at the time we were engaged in formal instruction. Greater numbers of learners are being accommodated by formal instructional programs for greater periods of time. For any given period of time, greater amounts of information and numbers of skills must be conveyed through the instructional program. Simply stated, it takes more information and greater skills for today's students to lead productive lives than was required of our generation of students. This suggests that if today's individual is to be productive for approximately the same amount of time as his predecessor, he must advance educationally at a more rapid pace. This further dictates that some new arrangement is required in the educational program of today's learners if this pace is to be achieved and maintained.

On the other hand, there may be several arguments forwarded which would support a policy of continuing as we have been with minimal attention given to individual differences. Presently large segments of our society receive impoverished educational experiences. In the long run society may benefit more through increased attempts to provide for these segments of our population those educational experiences which to date have been reserved for the more affluent segments. Innovation (e.g., adaptation to individual differences) is costly and can be successfully implemented only when conditions are right. Some evidence suggests that impoverished areas are not ready for innovation and must be brought along to a point where they are capable of profiting from innovative action. Two examples may help to clarify this point.

In Oregon a Title III (P.L. 89–10) project is operating which was designed to promote innovative practices leading towards individualized instruction in 45 secondary schools. Most of the participating districts have been able to identify an innovative activity and, through the use of the Title III support, progress towards implementation of the innovation.

One particular district has not been so successful. Although the staff was able to identify an activity leading towards individualized instruction, it became evident to the staff and administrator that completion of the activity would require investment of staff time that could be used more profitably in clarification and strengthening of basic educational offerings in terms of the community composition and needs. Individualization at this point was a superfluous exercise tangential to the basic problems of the people in the community.

There is a growing body of evidence that investment of innovative ideas, equipment, and materials is having little impact on achievement levels of students in impoverished areas served by Title I (P.L. 89-10). Of the many dimensions along which education may be described, e.g., physical plant discriptors, per pupil dollar expenditure, instructional media available and employed, teacher-pupil ratio, *ad infinitum*, only one characteristic, teacher quality, consistently differentiates Title I and non-Title I schools. This suggests that if we could provide the quality of teacher found in moderately affluent America to impoverished schools, a large number of students would profit with a resultant increase in the talent pool of the nation.

The decision is an economic one — "Where should we invest the dollars to ensure optimum return?" The purpose here is not to resolve this question. One solution is not to be made to the exclusion of others.

There are several ways that one might consider rearranging the instructional program. It is obvious that unique instructional strategies and approaches are required for different types of skills and contents. Gagne (1965) has documented this nicely by identifying various learning conditions which must be established relative to different instructional outcomes or goals. Schalock in the previous paper has also pointed out that learning strategies and or theories are differentially appropriate for outcomes in the psychomotor, cognitive, and attitudinal domains. It might well be that research will indicate that particular types of strategies are more appropriate for outcomes in a particular instructional domain, and can be effective in increasing the rate of acquisition of information, and skills. Such research will probably follow a model very similar to the one previously followed in learning and instructional research, i.e., a model which produces the best fit between independent variables (instructional strategies) and a dependent variable (learning outcome), "on the average." While this might be the case, this particular research model also contains inherent traps, in that it tends to result in many situations where the investigator finds no reliable differences between his independent variables and the learning outcome under investigation.

As many of you know, a simple thermostat, used to regulate heat input into a room, operates on the basis of the movement of a strip of two metals fused together. Various amounts of heat will cause the metals to expand differentially based on their own unique densities. Let's assume that the physicist who first noticed this characteristic had conducted his experiment in the same manner that we conduct many of our learning experiments, i.e., by attaching one end of a strip rigidly to a point and allowing the other to move up and down on a calibrated scale depending on its expansion. Having composed his strips of randomly matched metal densities he may have proceeded to apply varying degrees of heat to varying strip combinations and noticed that some strips moved upward on his calibrated scale and other strips moved downward. Choosing a fixed number of temperatures under which he was going to observe this phenomenon and applying each temperature to his sample of strips, he might very well conclude at the end of his experiment that no significant differences were noted for the various temperature conditions, an unfortunate conclusion. Jensen (1967) used a similar example in which he asked us to imagine a drug capable of speeding up the learning process for a particular type of learner. By random assignment of learners to each of two groups (a "drug" and a "no-drug" group), one could conceivably imagine a conclusion that no differences in learning rate were observed between the two groups, that is, that the drug had no significant influence on the learning process. The fact of course is that when results of treatments are averaged out over randomly assigned groups of subjects, the interaction of the particular treatment with individuals often goes unattended.

Hovland (1939) conducted one of the classic experiments of massed versus distributive practice on rote learning. His study revealed that there was no significant difference in rote learning between the two learning strategies, i.e., massed and distributed practice conditions. Hovland noted, however, that 44% of his subjects did better under distributed practice conditions and that another 38% profited more from massed practice. The point is of course that Hovland in his experiment had a situation where individuals were responding differentially to treatment conditions, a point verified empirically in succeeding experiments.

Another example is reported by Hovland, Lumsdaine and Sheffield (1949). Their study sought to determine whether a persuasive message was more effective when it contained both sides of an argument or only the side of the argument seen as positive by the originator. Their findings were that both types of message were effective but that the one-sided message was most effective for those who were initially favorable and the two- sided message most effective for those who were initially opposed to the idea.

The preceding has been a rather firm indictment against courses of action which fail to acknowledge the role that individual differences might play in the educational process. This indictment, while reflecting the writer's personal bias, is not a peculiar one. Instead it is the reflection of many behavioral scientists who have stated their rationale often and succinctly. Discounting that this is a biased position, let's turn to a consideration of alternative strategies which can build upon the uniqueness of the individual.

Methods for Adapting to Individual Differences

Cronbach (1967) summarized five possible adaptations or modifications of instruction which could account for variability in learners prior to the onset of instruction at any given point. These alternatives and the conditions which lead to them are presented in Table 1.

EDUCATIONAL GOALS	INSTRUCTIONAL TREATMENT	POSSIBLE MODIFICATIONS TO MEET INDIVIDUAL NEEDS
1. Fixed	Fixed	1a. Alter *duration* of schooling by sequential selection (i.e. continue schooling only for those expected to profit) 1b. Train to criterion on any skill or topic, hence alter duration of instruction, regardless of how long it takes.
2. Options	Fixed within an option	2a. Determine for each student his prospective adult role and provide a curriculum preparing for that role.
3. Fixed within a course of program	Alternatives provided	3a. Provide *remedial adjuncts* to fixed "main track" instruction. 3b. Teach different pupils by different methods.

Table 1. Patterns of Educational Adaptation to Individual Differences (Adapted from Cronbach, 1967)

As may be noted in the table, Cronbach is dealing with the fact that goals are either fixed (i.e., a specific set of goals expected for all or most learners), or optional (i.e., differential goals for specific groups of learners), and that instructional treatments are for the most part fixed, but in one instance may be variable. For the most part I think it can be assumed that most educational goals are fixed. Even in the case where Cronbach identifies goals as optional, his reference to goals here must be considered to be the broader educational goals of the instructional program, rather than the specific behaviors that one of the tracks or segments of that program might contain. The work of the instructional technologist is more concerned with specific and thereby fixed goals of instruction.

Considering the first row in Cronbach's matrix, where the instructional goals and treatment are fixed, two alternatives (1a and 1b) are available. Alternative 1a, alteration of the duration of school through sequential selection, suggests that a strategy of selection be employed. Certainly in American education, historically, and to some degree currently, processes of selection, natural and contrived, have been operational. In essence this type of selection has said that certain students are capable of going only so far and beyond that point can go no farther. In America we have permitted this to be a somewhat natural function, dictated by the capabilities of the learner and to a large degree by his social and economic position. The European model, on the other hand, has historically relied more on social bases for selection and recently upon psychometric bases for making this decision.

Alternative 1b, the training of all individuals until they reach criterion on any given skill or topic, also leads to a situation where individuals remain in the instructional setting for varying lengths of time. The difference, of course, is that the abler student under condition 1b moves out of the system more rapidly and the less able student (and here I am using the term "able" in its broadest sense) remains under the influence of the instructional system for a longer duration of time. We have no precedent for this type of alternative in American education with the possible exception of those graduate students who remain on campus for seemingly interminable periods of time; undergraduate programs similar to those established at Parson's College in Iowa; or specific skill training programs (e.g. aircraft pilot training) where hands-on performance is withheld until specific criteria are met. The feasibility of employing this alternative in the pre-college situation of course is questionable. While not documented, it is almost certain that if educational goals and instructional treatments were rigidly maintained, there would be large numbers of learners who would never complete current pre-college educational programs.

Alternative 2, the determination, for each student, of an appropriate adult occupational role with provision of a unique curriculum designed for that role, has had some precedents in American education. Although never carried to the degree that the decision as to which curriculum to follow was entirely removed from the student or his family, and certainly to the degree that this decision was made early in the student's career, the comprehensive high school of the early part of this century certainly was a step in this direction. Some residual features of this approach remain evident in our secondary schools today and current moves are afoot which would suggest a return to this type of structure in today's secondary schools. It is a dangerous position to follow both from the point of view of the individual and from the point of view of the society. From the point of view of the individual, early occupational decisions, whether made by the individual or by the school, can result in misclassification and misdirected effort. From the point of view of the society the decision could result in preparation for occupations which become obsolete midway in the work life of the individual resulting in the necessity to establish large scale retraining programs necessary to maintain the viability of the society.

This leads us to the final two alternatives outlined by Cronbach, the provision of remedial adjuncts to accommodate an individual when educational goals are fixed, and finally the identification of a particular instructional strategy to fit a particular student. The first of these later alternatives, remediation, has been exercised in many ways. Commonly school districts provide special programs for student unable to maintain an "appropriate" pace through existing curricula. Not commonly, teachers will provide additional instruction for individuals within their class when these individuals are unable to maintain the pace of the class established by the teacher. The underlying assumption to remediation, of course, is that once the student has eliminated his deficencies he may rejoin the rest of the group ready to try again. Logically it can be expected that remediation will lead to improvement in many important aspects. All too often, the group, continuing at its pace, has tended to move even farther ahead of the remedial student; thus placing his future success in a tenable position.

This leads us to the final alternative, the adaptation of teaching strategies unique to the pattern of characteristics which define any particular learner. There is no doubt that this, in and of itself, constitutes a horrendously difficult but, at the same time intriguingly challenging task. In essence it suggests that we match each of the myriad of educational outcomes in the three broad areas with which education is normally concerned, i.e., psychomotor skills, cognitive acquisition, and attitudinal outcomes, with the equally comprehensive list of ways in which learners vary. At the one extreme it says that we must prescribe for each learner a unique instructional sequence and strategy for each skill we wish him to attain. I must admit that it is unlikely that we will ever attain this level of sophisticated adaptation. Even if we were to engage in the thousands of man-years of research required to permit such adaptation, it is highly unlikely that our society or any society could foot the bill for such an education.

The magnitude of the task and the potential lack of economy does not suggest that we abandon the cause of searching for adaptations or instructional strategy to individual differences. Instead it suggests that we search for a middle ground that will provide the best fit between economy and instructional efficiency. While there have been almost no large scale efforts directed towards adaptive alternative 3b, there is a great deal of evidence, albeit fragmented, upon which we could base efforts to reach this middle ground.

The role of the instructional technologist is one of playing his hunches as to what expressions of individuality are most likely to interact with his message content in a significant way. Lumsdaine suggested at a recent symposium* that a first step towards reaching this middle ground is to "know thy audience." The audience for which a message is intended is composed of individuals all of whom possess unique sets of characteristics. At the same time, similar patterns of characteristics are possessed by groups of individuals within the audience. The number of such patterns or genotypes (Ensen, 1967) is dependent upon the homogeneity of the audience, and the nature of the message.

Edling (1963) designed two messages to modify attitudes toward further education for specific groups of high ability noncollege-bound high school students. Using value patterns as a categorizing variable, current research by Edling suggests that six messages are sufficient to reach over 90 percent of a large sample of eighth graders. Similar groupings conceivably could be found for messages within other content domains. For the remainder of this paper I would like to address myself to some of this research and alternatives suggested. This review will be selective; however, it is not intended to be limiting. Consider it, on the other hand, to be suggestive. It will be concerned with individual differences in (1) motivation, (2) aptitude, (3) race culture, and, (4) previous experience.

Motivational Differences

The role of motivation in learning is one that has received considerable attention by psychologists in many specialized fields. Certainly it has been a point of concern to the educator who would probably, if he were a classroom teacher, pinpoint this as one of his major concerns. While the problem has created a great deal of concern, it is probably one of the areas about which those of us in education have the least amount of information. From an educational point of view, our familiarity with the concept of motivation has been less with the ways in which individuals' motivations differ than with attempts to find techniques to increase the motivations of our students to acquire or work towards the goals we have established for them.

* Teaching Research Symposium on Contributions of the Behavioral Sciences to Instructional Technology. Salishan, Oregon, February 1968.

If one were to exhaustively peruse the literature on motivation; he would uncover a wide galaxy of theories attempting to describe human motivation. Adaptation or utilization of any one of these theories to formal instructional settings is never totally satisfying. Bits and pieces of each theory, however, tend to explain some of the situations which occur. Let's consider one of these theories in which there is evidence to support certain situations in American education.

Maslow (1943) defined a theory of motivation based on a hierarchical arrangement of human needs. Maslow identified five such levels of needs, physiological, safety, love, esteem, and self actualization. Maslow postulated, and there is a research base which tends to confirm his thesis, that a condition of prepotent contingency exists between the five levels of needs. This is to say that physiological needs are more basic than love needs and so forth. The concept of prepotency suggests that individuals will experience needs in the next higher classification only to the extent that needs in the more basic levels have been previously or concurrently satisfied. There is evidence that when basic physiological needs, such as hunger or thirst, exist in a deprived state the human organism directs almost all of his energy towards the satisfaction of these needs. There is some evidence that suggest that educators are becoming aware of this concept and are finding it necessary to provide increased nutrition for students so they might more capably profit from the instructional experiences of the schools. This sort of activity by educators is also consistent with growing evidence (Randal, 1966) that protein deficiency results in retardation of human cognitive capabilities. While Maslow was explicit in pointing out that individuals differ in terms of the level of needs being experienced, his theory did not address itself to the variation of individuals who are fixated at any given level within the need structure.

As an adjunct to his theory, although not an integral part of it, Maslow did attend to a field of motivation which he characterized as being a type of cognitive motivation. Generally speaking he referred to this classification as the need to know and the need to understand, the former being prepotent to the latter. Under this classification he made reference to the motivational role of curiosity, learning, philosophizing, and experimenting, and concluded that while these terms should be considered as basic needs unique to the human organism, they operate somewhat independently of the previous levels of basic need.

On a purely logical base we would probably conclude that such motivational conditions as curiosity and the need to know are probably the most crucial to our understanding of formal learning experiences. They would even appear to be powerful determinants of informal learning behavior. The problem is that we know very little about the ways in which individuals differ with regards to this type of motivation and even less about techniques which would enable us to identify individual differences of this type. Maslow was content to suggest that these types of behaviors were probably reserved for individuals possessing higher levels of intelligence. But certainly the correlation between amount of motivation and intelligence would be less than perfect and probably of an order too low to permit successful selection and or prediction of this behavior.

Prentice (1961) suggested several qualities of motivation potentially operant within the cognitive domain and in need of research. Unlike Maslow's theory, which postulated the presence within the organism of specific classes of needs and viewed motivation as a process of need reduction, Prentice's paper focused on qualities inherent in an activity or object. His suggestion was that certain levels of these characteristics in the activity interact with characteristics within the organism in such a way that the activity does or does not have attractiveness for a particular individual. Implied is the notion that individuals will engage in activities which for them are inherently attractive. Prentice suggested that activities should be studied in terms of their novelty, provisions for change, unpredictability; surprise and difficulty. Although there is little evidence relative to the degree to which each of these concepts; singularly or in combination make an activity attractive for various individuals, they are potentially useful points from which to begin a study of the motivational aspects of media or any other type of learning situation. Novelty suggests a certain degree of uncertainty in a situation or activity. Individuals likely differ with regard to the amount of uncertainty they can tolerate in any given situation or activity. Novelty or uncertainty is introduced into an activity through some form of stimulus variability. It is possible that humans when placed in a learning activity seek to maintain a stable relationship with their environment by selecting out of this environment those stimuli that tend to bring about and maintain an optimal (for the individual) arousal level.

Relationships between performance and arousal (creation of attention through stimulus variability) have been investigated previously and considerable support has been obtained for the "optimal level" relationship (Duffy. 1962; Freeman, 1938; Hebb; 1955). Other evidence has accumulated to indicate how the reticular system in the brain stem functions as an arousal and attention mechanism (Wooldridge; 1963; Lindsley; 1960; Magoun, 1958). Research on observing behavior, however, since Wyckoff's (1952) initial contribution has been minimal and in the area of instruction almost nonexistent.This lack of research is probably a function of inadequate measuring devices. Holland (1957) devised a technique which translates visual observing responses into key press responses. Using this procedure Holland (1963) observed significant relationships between observing response rate and rate of signal detection by subjects who had received an arousal producing drug and variable interval reinforcement for signal detection. Dardano (1965) also demonstrated that observing response rates could be controlled through utilization of differential reinforcement schedules. It appears then that orienting or observing behavior can be strengthened, weakened or maintained at a constant rate by introducing more or less novelty or uncertainty into a sequence of instructional events. While none of the authors studied this from a conceptual referent of individual differences, it is reasonable to assume that such differences do in fact exist and could possibly be utilized in the organization of instructional activities.

One final note on creating situations in which the learning activity becomes attractive should consider the concept of cognitive dissonance based on the work of Festinger (1957). With due apologies to Festinger I would like to briefly define the concept of cognitive dissonance. An activity becomes more attractive to the extent that the individual finds his behavior in the activity inconsistent with his attitudes towards the activity. In essence this suggests that dissonance can be created for an individual if his behavior in a given situation is at odds with his stated and preconceived attitudes towards the situation. It follows that when such dissonance is created for the individual he is attracted towards the situation in an attempt to modify his behavior so that it becomes more consistent with his attitudes. It may well be that this paper has been an attempt to create dissonance in the readers. I am assuming that most of the readers hold positive attitudes towards the adaptation of instruction to individual differences. At the same time I have attempted to show that much of our behavior has been such that we have failed to so adapt instruction. If I have been successful, therefore, I have likely established varying degrees of cognitive dissonance in those of you who are sensitive to this point. Festinger would hold, and I would hope, that this dissonance would attract you to situations in which you are given the opportunity to reduce the inconsistency between your behavior and your attitude.

On the practical side of things, not a great deal has been done in identifying individual differences in cognitive dissonance in different situations, however, the elements are present for so identifying such differences. Samples of behavior in varying situations may be observed and attitudes towards such situations can be assessed. Given these basic elements the instructional technologist should be in a position to begin making rough estimates relative to the amount of dissonance present which in turn could lead to development of adaptive instructional sequences.

Another approach to motivation worthy of consideration is that of achievement motivation (n Ach) which is primarily identified with Atkinson and McClelland and is defined as the desire to engage in challenging situations in which moderately difficult goals can be *established* and *reached* through hard work by the individual (McClelland, 1966). This is one explanation of motivation that has received a great deal of attention from the individual point of view. This is perhaps a function of the fact that the concept itself was derived from a measurement base Educationally, n Ach has not been shown, in any consistent manner, to be related to academic achievement in educational settings. A possible explanation of the lack of failure to demonstrate any consistent relationship between the need and school achievement has resulted from a misinterpretation of the need itself. With one or two exceptions, which will be covered shortly, attempts to relate n Ach to school success have been instigated by persons primarily identified *within the educational arena*. It is not difficult for the "outsider" to fall into the semantic trap of equating the meanings of the word achievement as expressed by the tag n Ach and as it is construed in the educational domain. In fact, the two uses of the word achievement carry with them quite different definitions. Characteristic of such studies are the following. Lesser, Kravitz, and Packard (1963) found no significant differences in the need of achievement exhibited by high and low achieving girls with similar IQs. Cole, Jacobs, and Zubok (1962) found significantly less achievement imagery among academically successful college males than among underachieving males. In a similar vein Jensen (1961) found no relationship between need achievement and academic performance of college age students. All three of the above mentioned studies were similar in two respects. They judged achievement in terms of school grades and used McClelland's TAT techniques for assessment of need achievement. At the same time other researchers have found need achievement to bear positive relations with several kinds of achievement behavior. Moss and Kagan (1961) sampling adults of both sexes from the Fels Research Institute longitudinal population found relationships between need achievement and behavioral attempts (1) to attain a self imposed standard of excellence, (2) to obtain symbols of status and recognition, as well as the relationship between need achievement and general concern with intellectual competence. London and Rosenhan (1964) summarize by saying:

> At this point, it almost goes without saying that a great deal more research is required on the relations between achievement imagery, variously obtained, actual achievement in laboratory settings, and achievement in life. Moss and Kagan's suggestion "that the concept of a general achievement motive is too broad a term, and it may be useful to replace this construct with a series of variables that relate to more specific behaviors" seems especially worth consideration in view of contradictions among research reports.

Even though the broad interpretation of the term achievement tends to lead some investigators up blind alleys, there is evidence that attention to achievement motivation might in the long run be rewarding. Cronbach (1967) identifies two motivational patterns: constructive and defensive. He defines the person who is constructively motivated as one that is high on achievement motivation and at the same time low on anxiety. Conversely the defensively motivated subject is one that is highly anxious while at the same time low on his need to achieve. Implications for design of instruction for each motivational type is suggested below.

Constructively motivated subjects tend to persist in situations which, to them, provide moderate risks. Defensively motivated persons, on the other hand, seem to be more persistent when believing that the chance of success is quite low. Kogan and Wallach (1964), using learning tasks which contained inappropriate as well as appropriate alternatives, found that defensive subjects became rigid when in difficulty and often unwilling to withdraw or move away from an inappropriate strategy. Constructively motivated subjects when given simple instructions telling them to get to work and do their best, achieve well; however, additional pressure tends to lower their score (Atkinson and Reitman, 1956). Addition of the same type of pressure, however, improves the work of the defensively motivated subject. Mandler and Sarason (1952) reported that low anxious students will improve performance when told that they are doing poorly, while improved performance requires favorable comments for defensively motivated students. While these studies have not been conducted within the context of the clasroom, they certainly are suggestive of possible application to classroom situations.

Two studies (Atkinson and O'Connor, 1963; Grimes and Allinsmith, 1961) suggest that in classroom situations defensively motivated subjects achieve more readily when short range goals are identified for them, instruction provides for a maximum of explanation and guidance; and arranges feedback on performance at short intervals. These same studies indicate that constructively motivated students achieve more readily when faced with moderately difficult tasks where immediate goals are not necessarily explicit and feedback is provided at longer intervals thus providing the teaching situation in which students learn to judge for themselves rather than rely on motivational support. Cronbach (1967) summarizes as follows:

> If defensives learn fastest under conditions of dependency, we probably want to arrange strongly supporting conditions for schoolwork we take most seriously. "But it would be shortsighted to restrict these pupils so that they remain defensive. Some part of the school program ought to be designed to increase their self assurance; only this will release their full potential (Sears and Hilgard, 1964)."

The preceding has been an attempt to briefly summarize some of the motivational research carried on by behavioral scientists, coupled with an effort to relate this thinking to the adaptation of instructional materials and media and to individual differences.

Individual Differences in Abilities

As a starting point in this consideration of human abilities and their relationship to learning behavior I should like to review the contribution of Guilford as reflected in his description of the structure of intellect (Guilford, 1959), and the position held by Humphreys (1962). Since the paper by Humphreys is the more recent and reacts to that of Guilford, let's look first at Guilford's structure of intellect.

Based on years of work by Guilford and his students, the structure of intellect describes human intellectual abilities in three major dimensions.

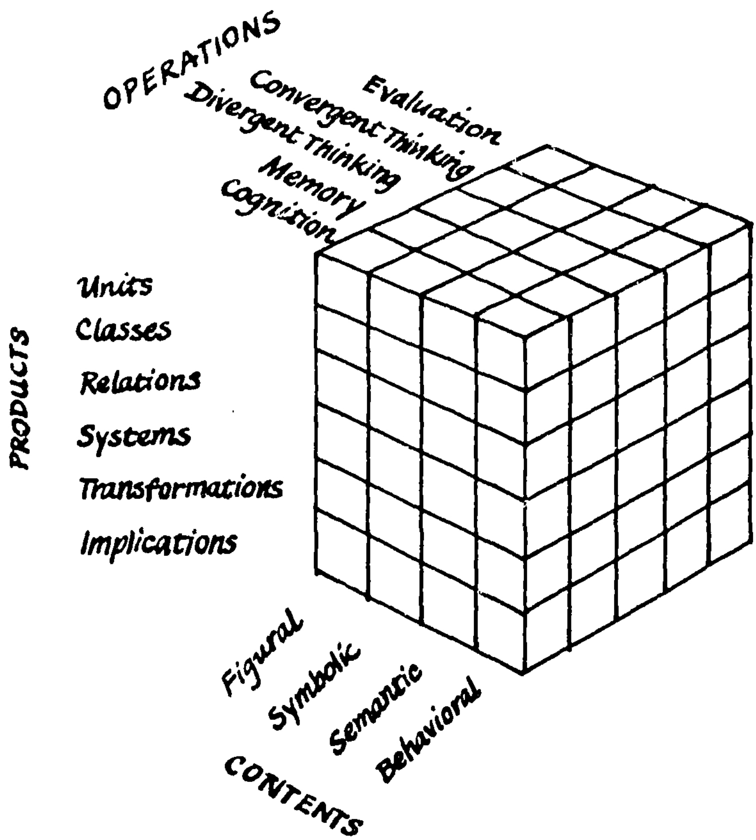


Figure 1. A cubical model representing the structure of intellect. (Adapted from Guilford, 1959)

Each of these three major dimensions, operations, products, and contents, contains several categories. The three dimensional model is shown in Figure 1. As can be seen, Guilford's research has identified five mental operations: cognition, memory, divergent thinking, convergent thinking, and evaluation. Each of these mental operations may be applied to one of three types of content: figural, which is defined by Guilford as concrete material which represents nothing except itself; symbolic, which is composed of letters, digits, and other conventional signs; and semantic, which is in the form of verbal meanings or ideas. The fourth category of content, behavioral, has been suggested by Guilford to represent the general given operation is combined with a given category of content, six kinds of products can be, and usually are, involved. These products are identified by Guilford as units, classes, relations, systems, transformations, and implications. The structure of intellect, therefore, defines a specific human ability as the interaction of a particular mental operation; a particular type of content and a particular product. Thus, the structure of intellect identifies 120 specific human abilities. Of these ninety abilities approximately sixty have been defined by specific tests loading substantially on them. Individual variability on each of these tests has been demonstrated. In light of the preceding discussion, this would suggest that adaptation of instruction to individual differences in ability would require attention to at least sixty distinct measures of human abilities. The problem, however, may be simpler than would be suggested by this myriad of human characteristics which would comprise a very complex profile for describing the intellectual capability of an individual.

If the model is viewed not only as the structure of human abilities but as Guilford suggests a structure of human intellect, it might be possible to look at learning outcomes utilizing the same parameters suggested by the model. Gagne (1962) has suggested that knowledge is structured in a hierarchical manner. In the same paper he suggests an approach for identifying this hierarchy. Gagne's process is one of identifying a given behavior followed by systematic identification of those behaviors subordinate to (i.e. required before the learner can, through instruction, exhibit the given behavior) the original behavior under consideration. Several instructional technologists (Kersh, 1964; Twelker, 1967; Hamreus, 1967), including Gagne, have suggested that the identification of this behavioral hierarchy is the appropriate first step in the design of instructional systems. To the extent that Guilford's structure of intellect model is sufficiently comprehensive, it should be possible to associate each of the behaviors thus identified with one of the combinations of mental operation, content, and product. This in essence then matches the learning outcome with the corresponding learning ability and might suggest a fruitful place to begin in considering individual differences which could be meaningfully related to that particular type of outcome. Some investigators (c.f. Christensen, 1963) have employed this strategy with success.

With growing awareness that tests of learning aptitude are more reflections of the learning experiences to which individuals have been exposed and less a function of innate human capability, classification of instructional outcomes in terms of the intellectual characteristics suggested by Guilford's model becomes even more intriguing. It suggests that if training were directed more specifically to groups of "instructional objectives-human abilities' the human abilities themselves might be enhanced. This is especially intriguing in terms of the more complex mental operations (divergent thinking, convergent thinking, and evaluation) identified in the structure of intellect. It is these types of operations to which we attach greater value in instruction within the cognitive domain.

Utilization of the structure of intellect model could provide considerable insight into the nature of capability patterns which characterize particular segments of the instructional audience. The approach to be employed by the instructional technologist might be one of (1) categorizing intended behaviors in terms of cells within the model to determine goal clusters, (2) identifying audience segments through analysis of performance on tests appropriate for the goal clusters, and (3) development of messages appropriate for the audience segments.

Let's turn now to organization of human abilities as viewed by Humphreys. In essence Humphreys suggests that human abilities are made up of a general factor which, in turn, is composed of several broad group factors, each of which is made up of several more specific factors. Humphreys' concern is that the work of Guilford and his associates has led to a fractionalized concept of the human abilities to the point that the abilities are so minute and so specific to a particular type of test behavior that they no longer become meaningful when applied to instructional situations. As Humphreys points out, Guilford now recognizes more mental factors than Thurstone had tests.

The criticism of Guilford's work seems to rest more on the methodological dependency and subsequent application of the methodology than on the power of the concept itself. Be that as it may, the model suggested by Humphreys, that is, a general factor made up of broad subfactors which in turn are composed of more specific subfactors is probably more representative or mental measurements as we now know them than is the model proposed by Guilford. The general factor suggested by Humphreys is undoubtedly closely related to the concept of IQ as we now know it, even though IQ can be shown to be a composite of several factors rather than a unitary function. To carry this further Humphreys' broad group factors which he identifies as subordinate to the general factor could well be identified with the subscales now attended to by many of the currently employed tests of mental abilities, e.g., verbal, quantitative, reasoning, or special ability. The problem of course is that individual variation on a large general factor (IQ perhaps) is not always predictive of performance in a given learning situation. I will speak more to this point later in this paper. While the research evidence is replete with findings that general intellectual ability is related to overall school achievement, relationships between general intellectual ability and specific learning tasks are equivocal, probably because the IQ composite is not composed of the same skills demanded by the tasks. Such limitations have been noted repeatedly and have resulted recently in greater attention to those abilities which Humphreys would probably identify as broad group factors.

There is general agreement that individuals possessing greater intelligence will perform at higher levels. That, however, is not the question we are concerned with at this time. Specifically we are concerned with the question "should individuals possessing different levels of general ability be instructed differentially?" As previously stated there is little evidence to support this notion. One of the early tenets of programmed instruction was that programmed instruction would tend to minimize individual differences in achievement whereas conventional classroom instruction tends to maximize individual differences in achievement. Stolurow (1964) attempted to determine the effect of sequencing in programmed instruction. Using a single, well-validated, instructional program, Stolurow had bright students and low average students complete the program under two conditions of sequencing, appropriate well-validated sequence and random sequence. He noted an interaction between sequence treatments and ability groups. Essentially the interaction revealed that the brighter students learned regardless of the sequencing whereas the slower students performed well only under the appropriate sequence condition. Stolurow concluded that the well-sequenced program did for the slower student what the brighter student is able to do for himself.

In an early study (Anderson, 1941) utilizing fourth grade subjects being taught arithmetic for an entire year, it was found that for those students whose past achievement surpassed expected achievement, explicative drill types of instruction result in greater learning. For the student whose mental ability would suggest a level of performance superior to what he had actually exhibited a more meaningful mode of instruction seems to be superior.

Zeaman and House (1967) summarized recent research dealing with relation to IQ and learning. Primarily their attention was focused on laboratory learning situations with subjects from a somewhat restricted lower IQ range. They report that for discrimination behaviors "at least a low positive correlation exists between an IQ (with MA controlled) and performance in visual discrimination tasks when a wide range of IQs is sampled and tasks of intermediate difficulty are used." These authors further summarize that IQ and verbal learning performance are positively related in both paired-associate and serial position tasks for subjects of equal MA. Since their review dealt primarily with laboratory learning situations the implications for classroom learning are not clear but should perhaps be considered as instructional systems are developed.

One final study (Stake, 1961) addressed itself to relationships between aptitude, achievement, and individual difference in various types of learning tasks. Stake's findings suggested that intelligence can be defined as ability to learn, however, factor analysis revealed four learning factors which accounted for the major portion of variability in learning score. Two of these factors were memory task factors, one a numerical task factor, and the fourth a concentration factor. On the basis of these results he concluded that no general learning ability other than that aptitude measured by intelligence tests is in operation. Instead, there are specific learning abilities required for specific types of tasks. In Stake's study Thurstone learning curves were generated for each subject on each learning task. For the most part it was noted that individuals exhibit considerable variability in learning rates, a characteristic that bears further investigation, even though such investigation would likely entail distinct studies for each type of learning task.

The preceding section has been an attempt to review some of the literature relative to individual differences in human abilities and the applications for design of instructional systems. I would like to digress at this point and consider the problem of ethnic differences, in learning ability.

Ethnic Differences as They Relate to Instructional System Design

It is with some trepidation that I even suggest that instruction should be adapted to differences in ethnic background. Certainly it is a volatile area but one which should at this time be systematically considered and explored.

Historically, ethnic differences have focused on differences in innate and culturally derived abilities of Negroes and Caucasians. Numerous studies during the past half century (see Drager and Miller, 1962 for a review) have attempted to shed light on the comparative intelligence of these two groups with attempts to determine whether observed differences are the results of innate differences between members of the two groups or the cultural situations in which the groups tend to reside. Much of the early research, depending on the geographic location of the investigator, has attempted to explain observed differences in mental ability of Negro and Caucasian groups in terms of cultural differences of the two groups. These efforts prompted several investigators to attempt the development of culture-fair tests of mental ability. Recent trends in assessment of human abilities has indicated that attempts to assess human ability independently of the culture in which the subjects have developed is a blind alley. Until we are at the point that innate human abilities can be reliably assessed through physiological means the concept of culture-fair assessment is simply inappropriate. Human abilities are developed *in situ*, and while there undoubtedly is an interaction between innate abilities and culture, abilities as we now view them should not be considered independently of the culture itself.

The study of ethnic characteristics is often hampered by an identification and classification problem. Seldom are pure strain samples available to the investigator. In attempts to identify samples of Negroes, investigators have found the problem exceedingly difficult and that color of skin, hair texture, facial features, etc. are often misleading indicants of ethnic origin. Racial mixes are by far the rule, with pure strain groups almost inaccessible in our society.

If it were possible, however, to identify pure strains of any given ethnic group, we would likely find comparative differences in many individual characteristics. The fact that the individuals represented would necessarily be products of different gene pools almost dictates that cognitive differences between groups would be found.

A recent study of Stodolsky and Lesser (1967) looked at patterns of ability for various ethnic groups and social economic classes. The investigators studied patterns of mental ability for Chinese, Jewish, Negro, and Puerto Rican samples of six and seven-year-old boys and girls representing the middle and lower socioeconomic classes. Four specific mental abilities were studied (verbal, reasoning, number facility, and special conceptualization). The study was carried on in an urban situation and the test materials were developed specifically for the project. In the development of the test materials, efforts were made to include experiences which could be considered common to all of the groups under consideration. The investigators found that each ethnic group was characterized by its own unique pattern of the four abilities considered. These patterns of abilities are revealed in Figure 2. The study further revealed that "once the pattern specific to the ethnic group emerges, social class variations within the ethnic group do not alter this basic organization." These similarities are shown in Figures 3, 4, 5, and 6. This latter finding was unexpected since preceding studies have almost unanimously revealed that social class status is a primary determinant of level and patterns of human abilities.

The implications of the consistency of ability patterns for social classes within ethnic groups is that greater stability of these patterns may be present than research suggests. The implication of course for

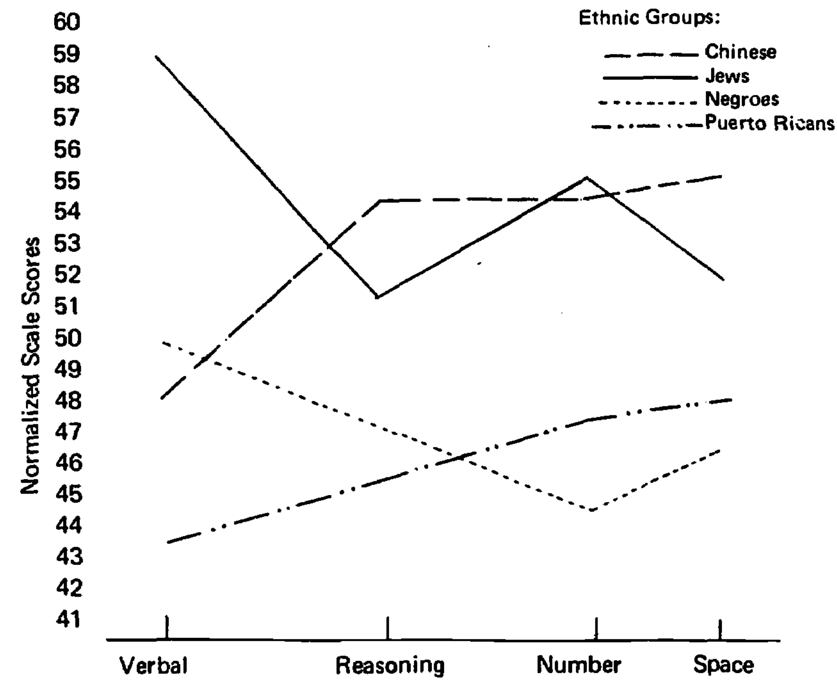


Figure 2. Pattern of normalized mental-ability scores for each ethnic group (Adapted from Stoldosky and Lesser, 1967)

adaptation of instruction is that instruction should perhaps be adapted to these differential patterns especially in those urban areas where large groups of these subjects reside. The further implication may be that provisions for instruction among disadvantaged groups may be simplified if the particular disadvantaged groups in question also possess a particular ethnic composition.

The original study by these investigators was conducted in New York City. A later replication of the study in the Boston urban area revealed remarkable similarities to the original.

The preceding portions of the paper have attempted to review some of the work that has been done by behavioral scientists that is related to individual differences in motivation, abilities, and ethnic origins. Obviously, these are only a limited number of ways in which individuals can be shown to differ. Lack of attention to such areas as perception, the culture, past experiences, and sensory modality just to mention a few, ould not be interpreted to mean that these areas are not seen by the

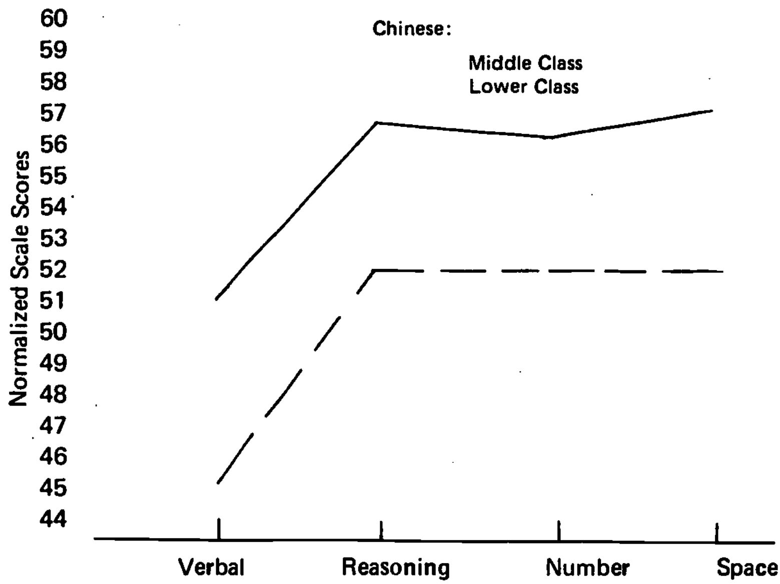


Figure 3. Patterns of normalized mental-ability scores for middle-and-lower-class Chinese Children.

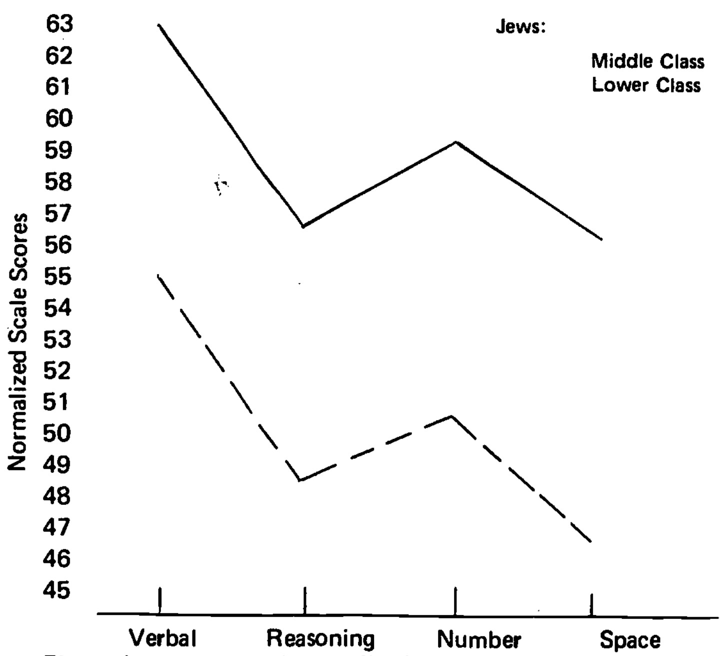


Figure 4. Patterns of normalized mental-ability scores for middle-and-lower-class Jewish children.

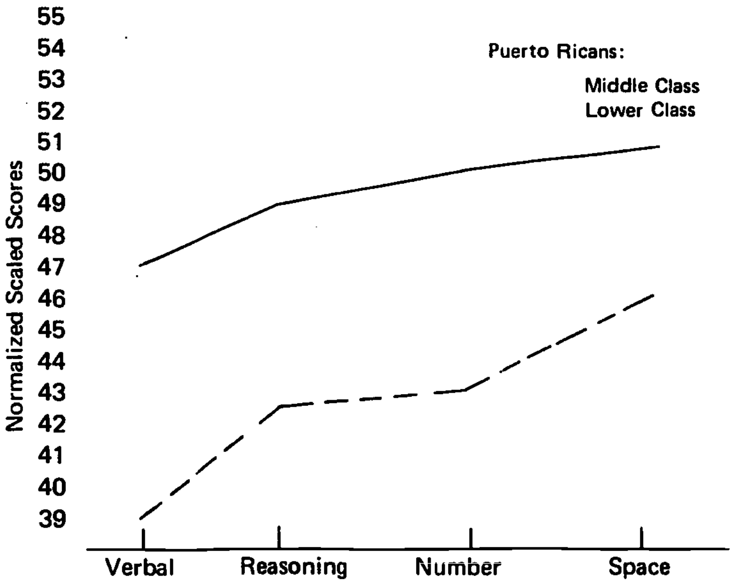


Figure 5. Patterns of normalized mental-ability scores for middle-and-lower-class Puerto Rican children.

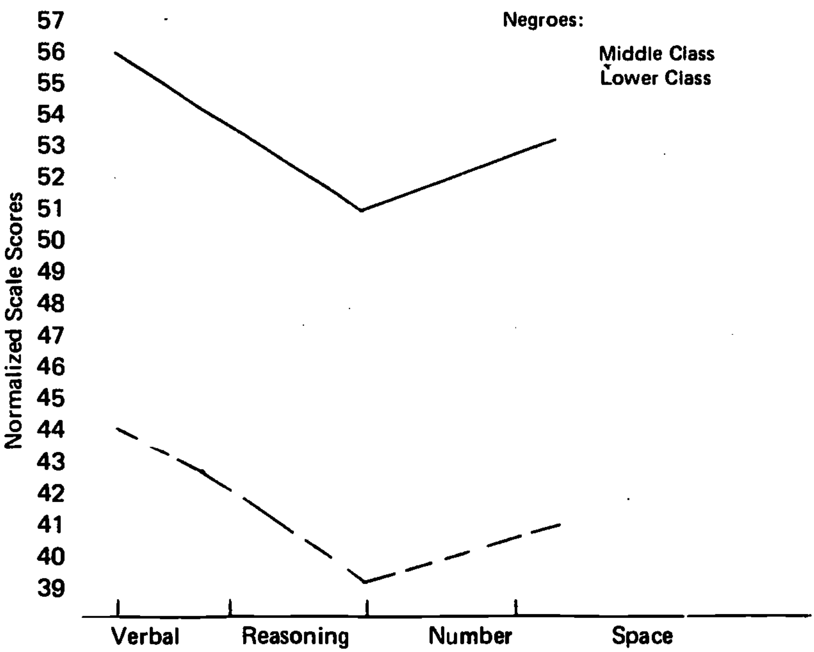


Figure 6. Patterns of normalized mental-ability scores for middle-and-lower-class Negro children.

writer as having relevance for the work engaged in by the instructional technologist. The concept of perception overrides many of these areas and while there is considerable evidence that individuals bring unique perceptual sets to learning activities, sets which may be identifiable prior to the learning situation, these influences are closely related to the attractiveness of the situation (motivation) and the arousal and attentional behaviors of the individual.

The historical factors of family and environmental influences, previous learning, and previous experience with various types of stimuli also need to be considered in the development of instructional systems. The differences which result from such histories, however, are probably the most variable of all the concepts previously considered in this paper. At the same time such historical data could likely be expected to explain many of the potential differences heretofore considered. Rich as such information might be for the design of instructional systems, it is unlikely that within the near future organized systems for retrieving and utilizing such histories will be available.

One possible solution to this dilemma might be found through the utilization of large data banks maintained and organized through the use of computing equipment. For example, in the Portland Public Schools such a system is currently under development This system couples the storage of student information with computer augmented instruction. That system is attempting to maintain a permanent record of the entire history of learning experiences provided to each student as he moves through the school system. This record, coupled with the student's responsiveness to the specific learning experiences, may permit not only prescriptive instruction for each student based upon his pattern of individual differences in motivation, abilities and learning history, but also may permit the accomplishment of basic research in the cognitive development of individuals.

A Suggested Strategy

At the present time, specific concrete knowledge relative to the influence of individual differences on instructional strategy is at best scanty. Limited as this knowledge may be, however, it vastly exceeds the attempts which have been made to adapt instructional strategy to patterns of individual differences in the development of instructional strategies, a condition as characteristic of the work of sophisticated instructional technologists as it is of the most naive teacher. Granted the addition of these types of variables to a systematic development of validated instructional sequences present severe methodological problems. It is further granted that the assessment techniques necessary for such adaptations fall short of the characteristics required. Even more crucial perhaps is the fact, as Schalock has pointed out previously, that currently available learning instructional theories consistently omit attention to the wide range of individual variation present. Despite these barriers, however, greater research attention must be given to this type of problem if our educational structure is to meet the needs of our rapidly evolving technological society. The task is too great to assign to a single discipline or intradiscipline orientation. Rather, the task will require an interdisciplinary approach; closely monitored with careful attention to the development of instructional theories. I think the instructional technologist; being somewhat of a generalist, can play an important role in the endeavor, his role being one of designing validated instructional systems utilizing a media where appropriate. To a large extent; the instructional technologist must become a unique practitioner, ready to employ the methodologies, concepts; frames of reference, and thought processes of anthropology; sociology, psychology, and engineering to the instructional tasks confronting him.

All investigators who become engaged in this task must take it upon themselves to identify domains of learner variables appropriate or seemingly appropriate to the instructional systems with which they are concerned and make efforts to include provisions for such variability within their validation activities. This suggests greater complexity in research models employed, e.g., inclusion of independent variables which reflect individual differences.

Finding the match between instructional sequence and individuality suggests that the research design must pay greater attention to the interaction of individuals with instructional strategy. This individual by strategy interaction will in most cases account for some of the variability in learning scores. Explanation of this variability is of course the goal for which we are striving. As I mentioned earlier in the paper, design models which do not look for this variability can lead us into serious errors.

My point is that individual differences exist whenever groups of subjects are exposed to learning situations. Investigators may have several alternatives available to them: (1) they may make attempts to provide for the differences prior to selection of subjects prior to their experimentation with the technique; (2) they could identify interactions between individual differences and learning treatment after the fact through attention to the interaction by treatment variation; (3) they might utilize multiple regression techniques looking for relationships between various student characteristics and learning outcomes. Whatever alternative is chosen, however, some attention must be given to individuality and learning strategy if we are to become serious about this form of adaptation.

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Understanding Instructional Media

J. V. Edling and *C. F. Paulson*

Focus

The primary purpose of this paper is to illustrate the applicability of media to a wide variety of problems. For example, the behavioral scientist employs media to gain new knowledge. The educator uses media to help attain educational objectives. Between these two general uses there is a large gap. The instructional technologist works to help fill the void. He takes inputs from both sources and seeks to determine outputs to both sources. But it is he, the technologist, who understands the uses and properties of media. Each user of media perceives his own special role for each medium, but the technologist perceives media in the totality.

The paper is not intended to be prescriptive or descriptive, but merely suggestive of what might be involved in "understanding" media. A "supplement" is enclosed to provide a few examples of the kind of discussion that could and no doubt should be conducted on each of the "issues" involved in each application of media. But even the issues listed are merely suggestive to assist in defining the possible application that is proposed.

There seem to be two kinds of people in the world: Those who can immediately identify the author and source of the expression "the medium is the message," and those who have never heard of media. So great has been the impact of Marshall McLuhan's book, *Understanding Media: The Extensions of Man*, that anyone discussing media feels that it is necessary to use this book as a reference point from which to identify his own point of view.

This paper is neither epilog nor sequel to *Understanding Media*, nor will it enter into an extensive analysis or criticism of that book. Our intent is to complement, rather than comment. Thus the fact that the kind of "understanding" that we seek to convey is different, and that we conceptualize media differently, need not be interpreted as conflict with McLuhan, except that we view his work as inadequate to our purposes.

It should come as no surprise that humanists and behavioral scientists differ radically in what they mean by the term *understanding*. There are also impressive differences with respect to what constitutes valid evidence, how evidence should be treated, and how conclusions should be expressed. The scientist thinks of *understanding* as being of a piece with prediction and control, the product of rigorous and painstaking inquiry, not instant insight. Yet our quarrel, if there is one, is not with the humanist, who pursues his own kind of inquiry with his own kind of rigor. Our quarrel is rather with those who mislabel insightful speculation as eternal truth. Man, when he is stressed, as he is stressed by media, has little tolerance for ambiguity, and an overwhelming need for certainty. Dilemma breeds dogma. Unanswerable questions beget unquestionable answers. It is our belief that any insight that is operationally meaningful is operationally testable.

We have expressed the belief that the *understanding* we pursue is different from McLuhan's. While his meaning for the term is perhaps implicit in his book, we shall not attempt to summarize his definition. We shall discuss what we mean by the term and invite the reader to compare for himself and draw his own conclusions.

Understanding, as we see it, is both a condition and an action, both *knowing* and *getting to know*. In the static sense, understanding involves both the possession of "truths" or "facts" and the awareness of their boundaries or limitations. It has been said that "a little knowledge is a dangerous thing." It is precisely this unawareness of the limitations of our knowledge that is dangerous. A physiologist is usually aware that his understanding of the human appendix does not qualify him to perform an appendectomy. In a sense, then, one who understands has both answers and questions.

The dynamic component, the act, of understanding involves answering questions and questioning answers, probing both our boundaries and the ground on which we stand. If inquiry is the reproductive system of understanding, then skepticism is its circulatory system. Without these vital processes, understanding not only cannot grow, it cannot survive. The more we know, the more we realize how tentative our knowledge is. The more we search for certainty, the more we realize that we can only reduce our uncertainty. Truth is like *West*. It is a direction, not an achievement. Understanding is employing tentative truths to unravel uncertainty.

Our approach to understanding, then, is not to provide ultimate answers, but to provide a means for developing progressively better answers. To this end we shall discuss media both as an object of inquiry and as a tool for inquiry. We shall pose questions or issues that have stimulated scientific research, "unanswerable" questions. Then we shall cite evidence, hopefully in such a way that the "answers" provided indicate both the way that the answers can be verified and the way they can be amplified, thus yielding "questionable answers."

There is another important divergence between McLuhan's approach and ours. From the point of view of empirical methodology, McLuhan's separation of the effects of media from the effects of their contents, which is the import of his statement that "The medium is the message," was fortuitous or insightful, or both. Sophisticated researchers have realized for some time that confounding content and media led nowhere, but McLuhan has made beautifully clear why this should be the case.

Unfortunately, again from our analytic point of view, McLuhan proceeds to make an organic entity of man and media. While it suits McLuhan's purposes well to conceive of media as extensions of man's central nervous system, we think it much more useful to consider media as extensions of events. As long as man and media are confounded, we can neither use media to understand man, nor man to understand media. Behavioral scientists, behavioral technologists and educators (educational generalists) are all concerned with events, with events as causes, as consequents, and with the relationships between the two. The fact that, by use of media, events may be arrested, transformed, and reconstituted, considerably enhances their tractability for investigation and their usability for instruction. We shall define media, then, as the energy (particularly sound and light) emanating from an event; they do not mediate neural impulses.

Lest we give the false impression that we have reverted to concern with content (events) rather than media, we hasten to point out that we are concerned primarily with the effects of mediation, with the import of decisions made in implementing the mediation process, and not primarily with the events mediated.

An Approach to Understanding Media and Instruction

The foregoing discussion has been an attempt to describe in general terms our concept of "understanding media." For the remainder of this paper we shall focus our concern on the relevance of media to instruction, so, in a sense, from here on we shall be speaking of "instructional media." Even thus delimited, the term is somewhat broad for our purposes. For example, it would include the teacher as mediator.

The nature of the research to be discussed, and the media properties that we consider very relevant to inquiry and instruction, dictate that we further delimit our concern to the technological media, sometimes referred to as the *new media*. To indicate the two restrictions we have placed on the general term *media*, we shall use the term *instructional* *technology*, which we define as the graphic, photographic, electronic, or mechanical means for arresting, processing, and reconstituting visual or verbal information.

An Approach to Understanding Instructional Technology

To simplify discussion of the multitudinous ways in which instructional technology may have immediate or ultimate impact upon instruction, we shall identify three primary uses of instructional technology:

1. *Study behavior*. The media serve as useful tools to study behavior systematically, *e.g.*, using film or TV to record behavior and then analyze it. Such behavior may include learning processes, instructional procedures, and even procedures of utilization of the media itself.

2. *Predict behavior*. These media also provide the means by which to develop specific stimulus configurations and establish the probabilities of various learner responses to those configurations, *i.e.*, they can be tried out until their effects are known or until desired effects are achieved.

3. *Modify behavior*. Instructional technology may also be employed to broaden the effects of effective instructional events. They thus become an effective means of mediating human learning to *attain* educational objectives when employed on a large scale.

These three applications are reminiscent of the scientific trilogy of understanding, prediction and control. This should not be too surprising, since we have more than a pretention, hopefully at least an aspiration, that instructional practice should be undergirded with scientific knowledge.

However, the articulation of basic understanding into effective social action is a complex and extended evolutionary process, requiring the integrated efforts of behavioral scientists, instructional technologists, and educational generalists.

Each of the three is concerned with understanding, prediction and control, but in each case a different concern predominates. The behavioral scientist is primarily concerned with understanding behavior, the instructional technologist with predicting behavior (or rendering it predictable), and the educational generalist with social control.

However, rather than confine any of these people to a specific domain, we have chosen to identify the three categories in terms of applications, not those making the applications.

The *Study* application is concerned with deriving useful principles describing reliable relationships that have broad significance or applicability. Prediction and control simply provide the means of assessing the validity and significance of such explanations.

The *Predict* application is primarily concerned with particularizing rather than generalizing. For example, it seeks to make statements about the configuration of behavioral effects attributable to a given stimulus event, or, on the other hand, to describe the configuration of stimulus elements required to achieve a given behavioral effect.

The educator (educational generalist) is primarily concerned with social control. Schools are expected to produce good citizens who can work productively and enjoy life. They are expected not to produce juvenile delinquents. Admittedly, the educator's ability to fulfill his charge is limited by the extent of his scientific understanding and the availability of instructional alternatives that have known and predictable effects, but the focus of his concern is in the area of control. Thus the *modify* application is concerned with making *general* use of the specific instructional tools developed by the instructional technologist. While the term "control" might seem more appropriate to some, it might prove deceptive to others. Hence we describe the application as to *modify behavior*.

The media, and particularly those we describe as "instructional technology," have three primary properties that render them particularly amenable to each of the above described applications.

The *fixative* property enables us to capture, preserve, and reconstitute an event. It is no longer ephemeral. It can be "consumed" without being "used up." In effect, this property permits us to transport an event *through time*.

The *manipulative* property enables us to transform an event in any of a number of ways. An event may be speeded up, slowed down, stopped, or reversed, scope be made broad or narrow. It may be edited, resequenced, interspersed or shown simultaneously with another. In short, the range of stimulus alternatives that may be presented in a given situation is enhanced infinitely by the media.

While the fixative property of the media allows us to transport an event through time, the *distributive* property permits us to transport an event through space, simultaneously, presenting each of the potentially millions of viewers with a virtually identical experience of an event.

The purpose of this paper is to analyze and consider effects and contributions or consequences of each property of technology on each of the *primary* uses of applications of technology with key unresolved issues identified and some evidence relating to the issues.

Topics are covered in the order 1.1, 2.1, 3.1, etc. as indicated on the following matrix.

INSTRUCTIONAL TECHNOLOGY

PRIMARY USES / PROPERTIES	1. Study Behavior	2. Predict Behavior	3. Modify Behavior
1. Fixative	1.1	1.2	1.3
2. Manipulative	2.1	2.2	2.3
3. Distributive	3.1	3.2	3.3

Edling – Paulson Matrix for Understanding Instructional Media.

1.1 Utilizing Media to Establish Learning Principles

The ability to capture, preserve, and reconstitute an event can have great significance to the behavioral scientist. This is particularly true in the case of the photographic and oral media which require no intellective symbolic translation or encoding. An event, whether a causal agent or consequent, can be scrutinized, analyzed, defined, and validated, again and again if need be. This capability is seen to be of considerable importance in view of the fact that both the stimulus events and the response behaviors with which behavioral scientists and educators are concerned are typically complex and ephemeral. Deprived of the ability to fix an event, the behavioral scientist would have two alternatives: (1) to keep his treatments and measures simple or molecular, or (2) trust to his observational and reportorial skill in capturing and defining antecedents and consequences. Being able to define clearly both antecedents and consequents is a necessary prerequisite to making clear statements about learning principles that explain their relationship. For example, a sociologist might record shall group interaction on film and the film record could be subjected to a variety of analyses to establish principles of small group behavior.

1.1 *Establishing Learning Principles*

The following *may* be examples of the kinds of issues that might be explored here. For a suggestion of the kind of discussion that might ensue from the issue and an example of evidence, please turn to the Supplement bearing the same identification number.

Issue:

1.1a Are conventional explanations of learning processes (e.g., contiguity, reinforcement, and field theories) adequate to deal with human behavior?

1.1b Does overt learner participation contribute significantly to human learning?

1.1c What is the role of motivation in human learning?

1.1d Is the concept of "readiness" essential in understanding learning processes?

1.1e Are there non-conflicting principles to facilitate retention and transfer?

2.1 Utilizing Media to Establish Instructional Principles

Media may be employed to systematically manipulate stimulus events and to observe the effects of the manipulation of such events, thus permitting the derivation of instructional principles. Stimulus events may be conceived of in sequences or as a static stimulus configuration. Within a given stimulus configuration it is possible to systematically examine the number of alternative stimulus elements. Thus, the number of modalities employed in a given configuration or the form of the configuration or the sequence in which such configurations are presented or the rate of their presentation can be manipulated systematically in any desired manner. For example, a mediated instructional sequence may be interrupted by the insertion of prompts to determine their utility in certain kinds of instruction.

2.1 *Establishing Instructional Principles*

The following *may* be examples of the kinds of issues that might be explored here. For a suggestion of the kind of discussion that might ensue from the issue and an example of evidence, please turn to the Supplement bearing the same identification number.

Issue:

2.1a Under what conditions should information be presented using only one sensory modality at a time, e.g., audio or visual, and when is a multi-modality (e.g., audio-visual) presentation more effective? (A rather extensive summary of Travers, et al., (1966) is provided in the Supplement because their report is titled "Studies Related to the Design of Audiovisual Teaching Materials.")

2.1b What procedures are useful in determining the amount of detail necessary for optimum transmission of information?

2.1c How can instructional materials be structured to facilitate retention and transfer?

2.1d Is the time lost in switching from one sensory modality to another a significant factor in designing learning experiences?

2.1e How is the concept of feedback (in contrast to knowledge of results) implemented in classroom situations?

2.1f Are there strategies of instruction that will significantly increase learning?

2.1g What amount of quantity of information should be presented to a learner without a break in the sequence or between a feedback interval for various kinds of learning tasks?

2.1h What is the role of color and graphic design in making instruction more effective?

2.1i Under what circumstances is an overt response superior to a covert response?

2.1j Does guidance or help to the learner in making a correct response facilitate learning?

2.1k What is the relationship between the modality of learning and modality of testing?

3.1 Utilizing Media to Establish Utilization Principles

The distributive property of media permits systematic study of the effects of any fixed configuration of media, on any desired behavior, in any setting, for all types of learners. The same stimulus events can be presented simultaneously under any and all conceivable conditions to determine commonalities and establish utilization principles. For example, studies may be conducted on television utilization practices to determine those which have the greatest effects on varying kinds of learners in varying situations.

3.1 *Establish Utilization Principles*

Issue:

3.1a What is the role of a teacher in a man-machine instructional system?

3.1b What provision in technological instructional systems must be made for teacher variables?
(Many studies indicate that the teacher contributes the major portion of variance in the effectiveness of any given instructional system)

3.1c What are effective strategies for the gaining acceptance of innovations?
(Some studies indicate that there is a great variance in the time that innovations are accepted among individuals possessing different characteristics. Apparently, early adopters and late adopters both require different approaches and require different amounts of effort in order for them to accept innovation.)

3.1d What are the effects of stress, isolation, training, and other situational factors over which there is little control in the utilization of technological developments?

3.1e Are there any utilization principles which consistently result in increments in learning?
(For example, VanderMeer's studies on optimum number of film showings) (Greenhill on TV studies).

1.2 Utilizing Media to Predict Behavior in Varying Settings

The fixative property of media permits reproduction (replication) of the same specific stimulus configurations in varying settings — enabling prediction of effects under varying instructional conditions. Thus, the instructional technologist can examine situational factors that influence the outcomes of technological modes of instruction. For example, a package of materials of "study skills" could be employed in a variety of instructional environments and their instructional effects rendered predictable.

1.2 *Predict Behavior in Various Settings*

Issue:

1.2a What is the most effective means for utilizing media in observing the effects on specific instructional configurations in given settings?
(There is evidence that participant observers observe different phenomena than what is observed by a motion picture camera or other recording devices. Apparently, each have certain strengths and weaknesses or deficiencies. However, there really has been no systematic manipulation of media in the observational role to

determine if its perceived limitations can be overcome through the use of multiple recordings and long range recordings and other techniques. (Schalock, 1967)

1.2b What is the influence of technological observation on that which is being observed? And how does one control for such influence?

1.2c What are the significant variables to observe and classify in varying situational contexts?
(One study revealed that removing one child from a classroom completely altered the climate of the classroom. Other than certain disruptive personalities, there are unquestionably other major classifications of variables which can be categorized and systematically manipulated.)

2.2 Utilizing Media to Predict Various Types of Behavior

The manipulative property of media permits development of varying specific materials, strategies, etc. to predict effects of specific stimulus configuration in developing varying kinds of behavior. This permits the instructional technologist the means to develop specific stimulus configurations and determine the probability of various responses to those configurations. For example, several different messages may be required to develop a positive attitude toward attending college, in learners with different characteristics within a given target audience.

2.2 *Predict Various Behaviors*

Issue:

2.2a In achieving a given objective, does one strive for a single optimum package that will achieve learning for the maximum numbers, or does one continue to develop different instructional packages as are required to achieve a given type of behavior?

2.2b What is the most effective method for deriving and stating objectives for use in developing a predesigned instructional material?

2.2c What are the unique requirements for developing instructional systems to achieve varying kinds of behavioral outcomes? (Cognitive, affective, psycho-motor)

2.2d With the increase in knowledge)n the number of objectives to be reached, how is it possible to design instruction and develop instructional systems at a rate comparable to the requirements?

2.2e What are the effects of various production variables on the development of desired behaviors?

2.2f Do media permit the measurement of behaviors that have previously been attainable because they have been unmeasurable?

(Film testing has enabled the identification and description of certain kinds of human interaction; for example, which previous instruments have not been effective in measuring and, since they can now be measured, they become an effective and feasible object of instruction.)

3.2 Utilizing Media to Predict Behavior Among Various Types of Learners

The distributive property of media enables specific pre-packaged learning experiences to be employed among all learners regardless of ability, wealth (socio-economic status), qualifications of teachers, etc. and still permit the prediction of numbers to be reached and the amount of learning among the varying strata. While the manipulative characteristic of media permits finding an optimum configuration for teaching a given behavior, and the fixative property permits capturing and using this configuration repeatedly, the distributive property permits utilization of the configuration as an extension of that configuration to an unlimited number of learners simultaneously. The problems of predicting the outcomes of various behaviors in various settings are multiplied greatly by the varying characteristics of learners. But, the great potentialities for utilizing the distributive characteristic of media only can be realized when appropriate technology is available in schools. For example, if schools do not have sufficient overhead projectors to enable teachers to use them on a continuing basis, then an instructional system with such a requirement cannot be adopted. For this reason one essential requirement for planning is to know the present status of available technology.

3.2 Predicting Behavarior Among Varying Learners

Issue:

3.2a What is the effect of entering behavior, behavioral repetoire, attitudes or prior education on the effectiveness of specific instructional systems?

3.2b How extensive must be the provisions for individual differences in actual practice?

(Is individually prescribed instruction significantly more effective than group paced instruction?)

3.2c How many times can a pre-packaged instructional system be employed before it becomes obsolete?

3.2d How available is the technology required to utilize instructional systems now being developed and requiring various quantities of materials in applied settings? (Godfrey, 1968)

1.3 Utilizing Media to Attain Educational Objectives Under Deprived Conditions

The fixative property of media permits the attainment of educational objectives even when teachers do not have the behavior in their repertoire or when needed resources and facilities are not available to the specific school district. For example, science demonstrations and laboratory equipment of a very expensive and esoteric nature can be provided via film at a fraction of the original cost and the same principles and insights can be achieved. The turnover in teachers suggests that it may never be possible through a teacher-mediated instructional system to achieve all of the behaviors that students require. Yet, the fixative property of media enables one expert teacher to be chosen and replicated when needed to achieve a given learning experience.

1.3 *Availability of Learning Experiences*

Issue:

1.3a Will a fixed instructional configuration lead to a kind of sterotypic or conformity type behavior?

1.3b What will be the attitude of teachers toward the use of predesigned instructional configurations when they feel that their unique contribution is the ability to interact with students in a spontaneous, un-preplanned manner?

1.3c What is the useful life of various kinds of pre-packaged materials? –

2.3 Utilizing Media to Attain Educational Objectives Most Effectively

Media can be manipulated for optimizing learning experiences to get the most effective possible learning. When the educator has a large repertoire of available instructional systems this will place him in a position to most effectively meet the expectations of the society in which he operates. For example, we understood that more than 1,000 schools are already interested in availing themselves of Glaser's *Individually Prescribed Instruction* program.

2.3 *Effectiveness of Technological Media*

Issue:

2.3a How are instructional systems evaluated in the context of specific situations to determine their optimal effects?

2.3b What are the requirements of instructional systems to gain maximum effectiveness in skill training, affective learning and cognitive learning?

2.3c What are the roles of simulators and games in achieving or attaining educational outcome?

3.3 Utilizing Media to Attain Educational Objectives Most Efficiently

The distributive property of media permits greater efficiency, that is, better use of personnel, resources, etc., to achieve more learning per dollar expended. For example, a study by Kopstein and Seidel (1967) indicates that present (1965-66) cost of instruction per student per hour in institutions of higher education varies between $0.89 and $11.10. If one accepts their assumptions, the cost for computer assisted instruction will cost between $0.40—$0.50 per student per hour. They have made liberal allowances for basic computer hardware, maintenance and spare parts, computer programming, instructional design and program preparation, and administrative overhead costs.

3.3 *Attaining Educational Objectives Most Efficiently*

Issue:

3.3a Who makes cost effectiveness decisions?
(One individual may make effectiveness decisions while another individual may be faced with budget realities and make cost decisions. Undoubtedly there is some pattern of maximum payoff for given expenditures, but who is to make these decisions and how are they to be made?)

3.3b How relevant are data generated in one situation in a different situation when all of the assumptions and conditions do not prevail?
(The issue of the generalizability of cost-effectiveness studies wherein all conditions cannot be met is highly problemmatical, e.g., assumptions on the number of hours that it is in use greatly affect the per student hour cost.)

3.3c What kind of information would the decision maker desire if any amount of information were available?

3.3d Decision maker may request information that is not most relevant to making a prudent cost-effectiveness decision and then the questions arise. What data is most relevant? How do you bring decision makers to where they employ the most relevant data in decision making?

3.3e When new technological systems are implemented, what follows in their wake in the form of support personnel, new organizational arrangements, etc.?

(Some of the status studies have indicated that there are many kinds of personnel costs other than those directly involved in instruction when new technological systems are adopted. State departments of education, school districts and local school systems all have support personnel of various kinds and these are growing at a rapid rate. The question in cost-effectiveness studies is how many of these new people are used to replace those who are no longer operative or contributing, and how many of the non-contributors are retained on the basis of tradition and other factors in various echelons of the educational system.)

Summary

With all due regard to the conspicuously profound insight of Marshall McLuhan, and the remarkable impact of his book, *Understanding Media: The Extensions of Man*, we feel that the "understanding" conveyed was inadequate to the needs of those who employ instructional technology in an instrumental manner. Thus we have sought to complement McLuhan's approach to understanding with another approach.

We conceive of instructional technology as a mediator of events. As such it has a unique capability to preserve and control events. We have drawn attention to the manner in which the ability to fix, manipulate, and distribute events can be utilized, and has been utilized, to study, predict, and modify behavior.

We hope that the resulting classification matrix, and the explication and application of it, will enhance the kind of "understanding" that goes beyond what has been done, to what should be done, and how it could be done.

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Supplement

1.1a: Postman (1961) concludes that "...the analysis of the process of audio-visual education does not call for the formulation of special principles; it calls for the application and elaboration of the general laws of human learning."

Smith and Smith (1966), however, state "Complicated perceptual-motor skills can be neither understood nor controlled in the traditional 'laws of learning' framework, and we are sure that this is just as true of the complicated integrations of sight and sound and of verbal and inverbal knowledge in the classroom. We believe that the analysis of audio-visual education *does* require special principles and special research designs going beyond the type of study championed by Postman and S-R learning theorists in general."

They go on to say that Gestalt psychology "recognizes some of the significant organizational features of human behavior but fails to extend its explanatory principles beyond the cognitive and perceptual level. Gestalt psychology emphasizes perceptual features at the expense of the complementary motor features of behavior and ignores the basic feedback mechanism underlying behavior organization. Because of its special emphasis on perception and cognition, Gestalt psychology has been incapable of generating critical objective behavioral studies that go much beyond rather general demonstrations. The S-R theories of learning have two general features that have prevented their generating significant research in the field of audio-visual communication and learning. One is the idea that all kinds of behavior, including non-verbal audio-visual patterns, are acquired according to the animal-based formulas of reinforcement learning or the association principles of verbal rote learning. Little credence is given to the idea that learning in audio-visual situations should be analyzed in terms of the operations involved. Audio-visual research can follow general learning principles from the psychological laboratories, but at some critical stage these theoretical ideas, if they are to be used at all, must be extended to fit the human operation of audio-visual communication. The fact that great difficulty is encountered in designing meaningful audio-visual research in a traditional learning context is in itself a good index of the limited significances of the conventional concepts.

"A second limitation of conventional thinking is the belief that any particular audio-visual device or medium of non-verbal communication has relatively invariant properties as an aid to verbal learning which can be studied and assessed independently of the operational situation. Kendler (1961), e.g., urged A-V researchers to develop a few 'basic research procedures' as a base from which to evaluate all the effects of audio-visual variables. This point of view does not recognize that audio-visual variables cannot be studied in the abstract but are a function of particular operational systems.

"The audio-visual research field needs more emphasis on the human engineering point of view than has been found necessary for research on other types of machine learning and training situations. This approach does not consider general learning variables of primary importance in understanding the effectiveness of instrumental teaching and training but emphasizes instead the influence of such design factors as the nature of perceptual display and the pattern of response control.

"The general inadequacy of reinforcement theory, as of all conventional association theories, is revealed by the many efforts of learning psychologists to classify or categorize the types of learning (Melton, 1964) The so-called general theories attempt to identify one or two factors which presumably account for all instances of learning, but in practice it is found necessary go beyond such general determinants as temporal contiguity and reinforcement and to distinguish among the various categories of learning—for example, classical conditioning, operant conditioning, instrumental condition, instrumental reward training, orientational learning, incidental learning, psycho-motor learning, probability learning, verbal learning, concept formation, and problem solving. In contemporary learning psychology, the problem of classifying categories and of analyzing their differences is a more general interest than the contiguity-reinforcement issue itself.

"In the cybernetic approach to learning, the so-called different types of categories are thought to reflect differences in patterns of feedback control. This approach recognizes no distinctive categories except in a general descriptive sense, for learning is assumed to vary quantitatively as a function of the variable properties, the integrative pattern, and the modes of transformation of the controlling feedback processes."

Evidence: At Ohio State University Egon Guba and his associates designed some instrumentation to investigate the characteristics of complex audiovisual material to try to discover more about what made them effective or ineffective. His device was designed to discover what visual cues learners attend to when they are presented audio-visual materials (specifically T.V.). Guba designed an instrument which would superimpose, electronically, a marker indicating exactly where the eyes were focused on a television screen. This was done utilizing the ophthalmograph principle in which a tiny beam of light sent into the eye was reflected into a small television camera. The subject was then asked to look at, and to follow, a moving light on a screen. The small T.V. camera was so adjusted that the reflected light from the eye followed precisely the moving light. Thus calibrated, anything the subject looked at on the screen was marked by a small round white spot of light

–not on the T.V. screen he was observing, but on a second studio screen superimposed, electrically, with the television presentation the subject was viewing. Guba then presented various kinds of instructional materials and subjects were studied to determine what they attended to. The data were in the form of kinescopes; that is, motion pictures with a white dot showing every eye movement and, of course, motion pictures are really still pictures which afforded the opportunity for detailed study.

The hundreds of thousands of pictures were then analyzed and they have produced some very surprising and unexpected findings. In essence, Guba found that even gross measures of intellectual ability, as identified by standardized intelligence tests, produced vast differences in viewing patterns. In some programs where an instructor was shown with some laboratory materials, slow learners never once removed their eyes from the mouth of the figure on the screen, even when the instructor was using the apparatus to demonstrate his points and was directing the learner's attention to the apparatus. However, with high *IQ* learners a very different phenomenon was occurring. The white dot of reflected light indicated that the bright student was attending cues in the learning materials which were very different in nature. The beam did not focus on the speaker's mouth, but rather it traveled rapidly over his face and hair line, over his clothing, then around the objects in the room and finally around the room itself in which the instruction was taking place. When apparatus was introduced onto the screen the dot was momentarily directed to the apparatus, it scanned its proportions, back to the instructor, and after a few seconds the dot wandered off the screen completely. In addition, detailed analyses of individual kinescope frames raised some very serious doubts about our existing notions of fixations and sweeps in reading and in the nature of the information that is gathered from graphic and pictorial materials.

1.1b: Some authorities argue that a more appropriate question is "For what kind of learners and for what kind of behavior are overt responses facilitative? Others argue with equal conviction that in complex learning situations typical of most human learning the function of securing active participation is to afford the learner an opportunity to get feedback as to the appropriateness of his response and to make progressively more adaptive responses in order to integrate them into larger organized patterns of behavior.

Evidence: Stake and Sjogren (1964) experimented with various "levels" of learner activity. They found that programmed materials were consistently more effective than the reading of conventional materials, and that making written responses facilitated learning over no written responses from program texts. But this superiority was not found when using "rudimentary teaching machines."

1.1c: Glaser (1965) states "When one measures the usefulness of a learning concept in terms of the extent to which it generates applications for instructional research and practice, the concept of motivation does not fare well. The theoretical and experimental concerns with this concept do not present readily translatable findings. In fact, many learning theorists have avoided the word in their conceptual thinking in the attempt to account for learning phenomena in more operational terms. In view of the state of the concept of motivation, one is tempted to say that motivation includes those events and operations that make a particular response-event contingency reinforcing. Such a statement is, in large part, an expression of ignorance of a variety of factors in the learning situation which need to be identified. Motivation, as studied, has been related to drives which are produced by certain experiences in an organism's history. In the laboratory, the operation of deprivation, e.g., of food and water, has been employed to make certain events reinforcing. It taxes one's ingenuity, however, to see how deprivation can be employed in instructional practice unless it can be conceived as withholding reinforcement.

"However, McDonald (1961) categorized audio-visual techniques as moti·ational devices. He did not deny that audio-visual devices might serve as specific instructional tools, but attached primary importance to their motivational devices. He did not deny that audio-visual devices might serve as specific instructional tools, but attached primary importance to their motivating value in arousing student interest and in directing attention to relevant aspects of a task. McDonald emphasizes the importance of using audio-visual devices to create *learning sets* to orient readers in the desired direction. He recognizes, however, that the orienting effect depends on the personality of the learner, as well as the nature of the audio-visual material. For this reason he suggested that audio-visual research should be concerned with the interaction between individual variables and the specific classroom and instructional procedures, identifying those which developed or resulted in the desired *learning sets*."

We wonder whether either of the above statements expresses the apparently critical role that individual motives play in varying learning tasks?

1.1d: Readiness, as conceived by developmental psychologists, is generally thought of as a function of maturation in previous learning and is considered by them perhaps the most central issue in human learning. But, Glaser (1965) states that readiness "has been rather ill-defined as specific responses that can be brought under the control of instructional procedures. Learning to learn, on the other hand, is concerned with inter-trial improvement in the course of learning and has been brought more fully under experimental control than readiness. As a result, 'learning to learn' defines a learning principle that is more ready for inclusion in an educational technology than 'readiness.' This distinction is discussed by Estes (1960)."

Is the concept of "entering behavior" a more useful one in understanding human learning?

1.1e: Some principles state that making an appropriate response in transfer situations is enhanced by stimulus generalization (responding to similar elements in the stimulus situations) and response discrimination (making differential responses to different stimulus situations). These principles suggests that retention and appropriate transfer is a kind of cut and dried, pre-determined affair. Other principles suggest that we do not want response discrimination but rather response generalization. Skinner (1959) states "An important goal is to 'enrich the student's understanding' by inducing him to permute and recombine the elements of his repertoire." This would suggest that the goal of much instruction is really not concerned with learning specific pre-determined responses, but rather to acquire a repertoire which may be considered more creative. What kinds of principles guide the appropriate behavior in all kinds of situations? Is the concept of lateral transfer and vertical transfer (a la Gagne) a more useful construct?

2.1a: A key idea of Travers (*et al.*, 1966) is that for the final utilization of information the nervous system has a selector or filter mechanism that appears to "involve a single-channel system of limited capacity." It must be kept in mind that there are very complex transmission, compression, and analysis systems before a final selector mechanism transmits information "in such a way that it forms a sequence ....corresponding to stored transitional probabilities....even though each event in the sequence may be complex." The point is that if "the utilization system is limited both in its single channel characteristics and also in the amount of information that can be processed through it" then why try to load up both the audio and visual modalities at the same time? It must be made clear, however, that "the concept of a single channel utilization system is basically a psychological one, and not physiological nor one derived from electrical engineering."

It should be made clear also that Travers does not necessarily or categorically advocate single modality presentations. "For example, in learning to associate foreign words with objects, should the word and the subject be presented simultaneously or sequentially? At first glance the model suggests that advantages may be gained by the sequential presentation, but this is not necessarily so. The simultaneous form of presentation may ensure a more rapid transfer of information into the perceptual system." (In later studies it was found that simultaneous presentation did in fact produce more learning (recall) than did sequential presentations. The experimenters explained their findings as follows: "This result may have been due to the contiguity of the stimulus-response pairs. In the sequential condition, each response item except the last was contiguous both to its stimulus and to the succeeding stimulus; whereas in the simultaneous conditions, the two members of each pair were linked only to each other.")

In designing instructional materials, then, would you fill both auditory and visual channels with a continuous flow of information? If not, why not? If so, under what conditions?

"Broadbent's theoretical model implies that only the informational inputs entering one sensory channel have access to the higher centers of the brain at any one time. The other inputs entering through other sensory channels are stored for a short time (a matter of only seconds) until the channel into the higher centers is free and only then can they pass through. Inputs which do not gain access fade and are lost. One would not expect multiple-channel inputs of redundant information to facilitate learning. The possible exception to this is the situation in which information is transmitted at such a low rate that the learner can switch from channel to channel and hence, perhaps increase his learning by having what amounts to an additional trial."

Evidence: In an experiment by Travers, et al., on a rote learning task the hypothesis was tested that "when redundant information is transmitted simultaneously through two sense modulities, more information is retained than when only one modality is employed." (Audiovisual modalities-long exposure times 4 or 2 seconds) "It was found that the auditory presentation was significantly less efficient than the other two and there was no significant difference between the visual presentation and the audio-visual presentation." (One variable studied was meaningfulness of material, and a significant interaction was found between nonsense syllable learning and the auditory mode - this suggests an explanation of the findings.)

In a second experiment similar to the one above, only involving shorter stimulus presentation times (1 and .6 seconds) it was found that "more was learned at the 1 second exposure time than at the .6 second exposure time, the auditory mode was still inferior to the other modes, but there was no significant difference between the visual and the audiovisual modes." It was concluded from these two studies "that the use of two sensory modalities has no advantage over one in the learning of material which is redundant across modalities."

Day and Beech (1950), reviewed ten studies which compared the relative efficiency of an audiovisual presentation of redundant information with the efficiencies of the auditory and visual channels alone." Most of these studies "provided evidence which was reported as supporting the position that a combined audiovisual mode of presentation was superior over the auditory or the visual channel alone." The findings of the experiments 1 and 2 above "do not agree with the earlier findings, but the failure to use tests of significance and the characteristically small differences for small Ns make the interpretation of these earlier studies tenuous. In the light of the greater controls used in this design and tests of significance it is concluded that the use of two sensory modalities has no advantages over one in the learning of material which is redundant across modalities. Indeed, there are indications that the simultaneous presentation of redundant stimuli at high rates of presentation could result in a decrement in learning as compared to the presentation of the same material using only one sense modality."

An experiment by Chan, Travers and Van Mondfrans was conducted to learn whether color-embellished nonsense syllables would interfere with the reception of auditory syllables more than would black and white symbols, and also whether more would be learned from visual messages than from audio syllables when there was simultaneous presentation of *non*redundant information. It was found "that the color-embellished visual presentation disrupts the processing of the auditory information more than does a black and white visual presentation," and "the amount learned via the auditory channel was significantly less than that learned via the visual channel." (Chan, A., Travers, R.M.W., and Van Mondfrans, A.P. [*A.V.C.R.*, 1965, 13: 159-164])

These data support earlier findings by Mowfray (1953-1954) which also indicate that more is learned through the visual channel than through the auditory channel when *non*redundant information is presented simultaneously through both channels. What is new is that more was learned via the visual channel under the color-embellished condition, but the *total* amount learned, i.e., through both channels, was the same. This means that while color-embellishing results in more learning via the visual channel "it occurs at the expense of the learning through the auditory channel."

In an experiment using a concept learning task [with problems in which the solutions required audio *or* visual information only, audio *redundant with* visual information (either complete), and audio *and* visual (both required for problem solution)] an attempt was made "to explore the effect of adding redundant auditory information to visual information, and vice versa." The findings suggest that there is no advantage "in providing redundant information through the visual and auditory modalities as compared with the transmission of information through the visual modality alone." The experimenters stated "Our suspicion is that other investigators are unlikely to discover tasks in which an advantage is gained in learning by transmitting redundant information through two modalities." However, this generalization holds only when the transmission rate is "equal to or in excess of the maximum rate at which the receiver can utilize the information; at slower rates of presentation one might expect that more information would be learned through bimodality presentations than through single modality presentation."

Would this suggest that we are almost back to where we started? We now may be more knowledgeable of facts on the operations of multiple modalities. However, the issue is no longer audiovisual vs. audio vs. visual, but what is the optimum rate for presenting information to learners of various capacities regardless of the modality employed.

Research on the problem of transfer from one sensory channel to another has been well reviewed by Asher (1964) "in an introduction to a series of transfer effects on vocabulary items in several lanaguages. While the studies comparing a redundant audiovisual mode of presentation with a nonredundant single channel presentation appear, on the surface, to support the claimed advantage of the two-channel presentation, a closer examination of them shows that none reported levels of significance and many of the observed differences were slight."

Earlier research summarized by Day and Beach (1950) and studies by Travers, et al.,(1956-1966) suggest that "with increasing complexity of stimulus materials, the visual mode becomes a more efficient source of transmission, whereas with increasing simplicity in familarity of the stimulus materials, the auditory mode becomes more effective." The issue relates to the appropriate time to use visual or auditory modes. The evidence suggests that as task complexity increases the visual mode tends to facilitate learning more than the auditory mode, but that the auditory mode tends to facilitate learning more when the task complexity is least." (Travers, et al., p. 97) One series of studies by Travers clearly "indicate the importance of hooking-up visual information with previously stored information through the use of verbal symbols. In addition, there appears to be a clear-cut advantage in transmitting the elements to be associated either with the more meaningful element first or with both elements simultaneously. The latter finding does not run counter to the single channel concept of information processing which has been embraced here since the evidence suggests that the presentation of two elements in a dyad simultaneously results in the receiver processing the familiar or more meaningful element first."

2.1b: A central notion in the work of Travers, *et al.* (1965-1966) is that present knowledge would suggest that a person's sensory receptors and nervous sytem "compresses" information provided by the environment at various stages durings its transmission. The compression process is defined as "the retention of that information which is the more critical to the receiver and the discarding of the less critical information: it is exemplified by the use of black-and-white line drawings representing full-colored natural phenomena which have a wealth of detail which the line drawing omits." The point, of course, is that if the information is going to be compressed anyway after it has activated the receptors, why not "precompress" it and get exactly what you want inside the learner rather than transmit a large number of irrelevant cues? At the very minimum Travers suggests, "while the virtues of teaching in realistic situations have long been extolled by audiovisual specialists, the precise nature of their virtues need to be identified."

The idea of "precompression permits a rational decision to be made concerning what is to be retained and what is to be eliminated, while compression by the nervous system involves at least some rather arbitrary processes." While the model does provide for a temporary stimulus holding mechanism that "permits the organism to utilize information provided simultaneously by two sources if the messages are short" (2 seconds), the selecting, monitoring and matching systems primarily "set up a set of priorities which have survival value." For educational purposes that may not be the only useful criterion, and it is suggested that "priorities can be changed by instruction given before information is mae available"

In designing instructional materials, under what conditions should one strive to eliminate irrelevant detail rather than strive for realism in communicating information? ("For example, a line drawing of the wiring of a television receiver is much more effective in transmitting information useful in assembling a kit than is a faithful photographic reproduction.")

Evidence: Experiments from compressed verbal information differ from visual information as the audio is already in symbolic coded form. Travers, *et al.* (1966) state "The argument is that those external methods of compressing verbal information which are similar to internal methods will best provide transmission of information. In the pursuit of this line of inquiry, we have to try and ensure that the redundancy removed is unnecessary for the transmission of information. This we can never be entirely sure that we are doing. Prior studies had indicated that there was an almost linear loss in comprehension as speed of verbal presentation is increased. Thus, some sort of efficiency index had to be calculated in order to determine an optimum level of learning. Prior research by Fairbanks, Guttman, and Miron, 1957, reported the optimum rate for the auditory presentation was about 280 words per minute in a study using a device which shortens the presentation time of materials by randomly discarding small bits of the recording message at rates from 175 words per minute to 350 words per minute.

"Efficiency scores were computed as the adjusted comprehension score per unit time of presentation. The same information was presented in an audiovisual form with the words being visually displayed at the rate paralleling the various compressed audio rates. The results clearly indicate an almost linear loss in comprehension as speed is increased. However, it was learned that while the auditory presentation was superior to the visual for the lower speeds, the visual was superior to the auditory for the higher speeds. The audiovisual mode was superior to both, suggesting that the individual differs in capability to handle one or the other mode of presentation, i.e., some people are better able to comprehend materials by one or the other modality, and the individual's preferred mode of receiving information was used in the audio-visual presentation. It does appear to be an individual difference factor in the capability to use either auditory or visual modes of presentation.

"When scores were converted into efficiency scores, representing amount learned per unit of time involved in presentation, it was found that the peak of efficiency was reached at about 300 words per minute. At the higher speeds, the audio-visual mode of transmission showed itself to be superior to the other two.

"While the speed of presentation which provides maximum learning per unit of time is about 300 words per minute, for both the auditory and the visual transmission, the auditory transmission tends to be consistently inferior to the visual. There appears to be an advantage to the simultaneous presentation of information to two modalities, and the advantage is more pronounced at the higher rates of presentation than at the lower rates.

"On questioning individuals following the experiment, it was also found that many individuals reported that they made an effort to block one channel and to receive the information primarily through the other. On the basis of these observations, it was speculated that the superiority of the simultaneous presentation was a function of individual differences in ability to receive information via the auditory or visual channel.

"A second experiment was designed to determine whether this difference became increasingly apparent as the speed of presentation was increased. It was found that the decrement in comprehension as a function of speed of presentation is very slight up to the speed of about 350 words per minute, where there is a very sharp drop in comprehension.

"The auditory presentations result in higher mean comprehension scores at all rates up to 400 words per minute, at which point the visual presentation results in higher mean scores. The audiovisual (two channel) presentation conditions present approximately the same relationship of comprehension to rate of presentation as do the single modality presentation conditions.

"There is very little difference in comprehension between the auditory and the audiovisual presentation conditions. The exception to this occurs at 400 words per minute, where the audiovisual presentation clearly results in higher comprehension scores than either the auditory or the visual presentation conditions. It appears that simultaneous presentation offers little advantage at the slower rates of presentation.

"The experimenters also concluded that a given subject does, indeed, make better use of one modality than of the other and that when pressured by the rate of presentation or density of information he tends to select or to use that modality which works best for him.

"One analysis of the data gave evidence that the order or presentation was an important variable. Careful examination of the interaction suggested there was a higher increment of learning when the visual presentation is followed by the auditory rather than the auditory presentation followed by the visual.

"In the latter studies college students were employed. The superiority of the audiovisual transmissions at the higher speeds of presentation is probably a result of the fact that this condition permits the subject to select that modality which he finds most acceptable to him under the given circumstances. At ordinary rates of speech presentation this effect does not occur and cannot be used as an endorsement of the practice of reading aloud the directions of tests, while the examinee reads them to himself."

The optimum speed in presenting verbal information is considered to be considerably above that which is commonly used for presenting lectures.

2.1c: Travers contends that information that is "stored is highly compressed and fragmentary, but capable of being reconstructed in such a way that something approximating the original stimulus inputs can be generated . . . an analogy is that electronic computers do not have to store logarithm tables in order to be able to produce the logarithm of any given number. All they have to store is a method of calculating logarithms." It has been demonstrated that electronic inputs to a computer can reproduce good representations (Cherry, 1962). In a similar way the brain may store fragmentary information that is "essentially rules for reconstructing the original information" (Travers, 1966).

Evidence: The first study by Travers, *et al.*, explores the extent to which a principle learned in a situation involving compressed visual information can be transferred effectively to the solving of problems in a new situation. A second study attempts to determine the role played by irrelevant cues when learning is accomplished in realistic situations and when the knowledge thus acquired is applied in situations which include either the same irrelevant cues or different irrelevant cues.

The second study also investigates the effect of omitting irrelevant cues, both in the learning and the transfer situation. In an experiment in which a transfer task required subjects to hit an underwater target with an air rifle and pellets, the effects of acquiring knowledge of the principle of refraction from physics under visually compressed or under realistic training conditions, were examined to determine which would best facilitate transfer.

In the first experiment it was found that the condition which contained all of the irrelevant cues was significantly better than the visually compressed condition which had most of the irrelevant visual cues removed. However, the experimenters suggested "it would appear obvious that it is not the presence of irrelevant information alone which can account for the facilitation of the application of the principle to a new situation. The establishment of a set prior to dealing with the visually compressed material appears to have had the same facilitating effect upon performance as the presence of irrelevant information in the realistic condition, i.e., it was hypothesized also that some of the line drawings compressed information in a psychologically inappropriate fashion, actually eliminating relevant information. When students were given the task to perform before they were given the principle, it was found that merely giving them the task previously facilitated their learning. In the initial experiment, the visually compressed treatment lacked a third dimension or even the illusion of a third dimension. Thus it may have actually been deficient in relevant information as compared with the realistic treatment. The general conclusion was reached that in solving a very difficult criterion task, the learner needs the same irrelevant and difficult cues as in the learning situation. It was concluded tentatively that the most efficient conditions for transfer exist where irrelevant cues present in the testing conditions are also present in the training conditions, and that the most effective learning as regards transfer occurs in the presence of irrelevant cues.

In the second experiment they wanted to determine whether the particular line drawings used omitted relevant information and they also wanted to determine the effect of the test situation, i.e., whether the presence or absence of irrelevant cues in the test situation was related to the presence of those same cues in the training situation.

It was found "that subjects trained under conditions possessing irrelevant information seem able to transfer their learning to test situations possessing irrelevant information or alternatively to test situations which reduced irrelevant information *equally well*. However, subjects trained under conditions of visual compression, i.e., with reduced irrelevant information, are less able to transfer their learning to test situations possessing irrelevant information than they are to transfer learning to test situatons with reduced irrelevant information — the assumption underlying the present studies was that the compression of information prior to reception by the eye would facilitate reception, since this procedure might spare the organism the task of discriminating relevant from irrelevant detail and would, hence, facilitate learning."

The argument seems to be both simple and straightforward, but what it does not take into account is the possibility that the effective learning of a principle also involves discriminating between the relevant and the irrelevant aspects of the situation in which the principle is applied. When a principle is learned within a framework of compressed visual information, the subject has no opportunity to learn to discriminate relevant from irrelevant features of the situation, for there are few irrelevant features present. The use of compressed visual information generally proved to be an ineffective method of teaching with the particular age group involved (sixth graders); "while the teaching situation involving compressed information provided all the knowledge necessary for understanding the principle of refraction, the pupils were not able to apply the knowledge they had acquired to the solution of a new problem as effectively as those pupils who had been exposed to a teaching situation involving a real beam of light bending as it reached the surface of the water."

A particularly interesting finding is that the group that had contact with a realistic problem before being explosed to the compressed visual information was able to apply the knowledge acquired as effectively as the group exposed to realistic training conditions. The data suggests that compressed visual information may be used effectively when the learner is familiar with the differences between the compressed information and the information that might be derived from a problem presented in a realistic setting. Under the latter condition, the subject may learn to discriminate between relevant and irrelevant features of a situation in which the principle is to be applied.

2.1d: If a task requires a learner to receive information alternately through the eye and through the ear is time lost in switching from one sense to the other and back again which reduces the time available for learning? This relates to the design of audiovisual materials in that it might be more important not to do much switching and to stick with a single modality for an extended period of time in making a presentation. Experiments (Travers, *et al.*) indicate that the switching time from one modality to the other is in the order of 200 msec (milliseconds). However, the evidence suggests that as modalities are switched back and forth, switching time for one modality to another requires an increasing amount of lost time. i.e., effect of switching is more marked on the fifth ...l than on the second. When the expectation is built up that information is to be received through the same modality, a change in modality makes switching become progressively more unexpected and hence increases the difficulty of making the switch and probably the time taken to make the switch. "This, in turn, leaves progressively less time for processing the information after the switch." Thus, "the decrement due to switching is dependent on the serial position of the switch, that is, the amount of disruption increases as the switch occurs later in the list."

Evidence: Travers (1966) states "The introduction of the necessity for switching sensory channels during the course of the presentation results in a decrement in learning, a decrement that can accrue either from time lost in switching or loss of stimulus presentation due to the operation of the filter. Phased somewhat differently, the use of bi-sensory presentations with high levels of information (compared to the individual's capacity) results in switching which detracts from the perceptual time. This increases the load on the perceptual channel and further increases the likelihood of an even greater cut of sensory input by the filter system. Switching time is estimated to be 160 msec., an estimate which corresponds closely to the estimates derived by other research workers involving entirely different procedures.

"A further point of interest is that the effect of switching is much more marked in the fifth position than in the second. Why this is so can only be a matter for speculation. One possibility is that the first four may build up an expectation that the information is to be received through the same modality and hence the transmission of information through a different modality is both unexpected and increases the time for processing the information after the switch." (Travers, p. 157 and 165).

2.1e: Smith and Smith (1965) state "In our opinion the most important conceptual development of post-war training science is the incorporation of the feedback idea into behavior theory." In general, the term feedback is used to describe a kind of reciprocal interaction between two or more events, in which one activity generates a secondary action which in turn redirects the primary action. Early mechanisms using the principle of feedback control were Watt's rotating governor on a steam engine and self-regulating temperature systems. Since World War II, the feedback principle has been identified especially with control systems known as Servo mechanisms such as are used to guide a ship or gun sight on a defined path in terms of a recorded error signal. "The feedback principle has found widespread acceptance among psychologists, partly because of its resemblance to the familiar *knowledge of results* principle of learning efficiency. Many psychologists use the terms feedback and *knowledge of results* interchangeably, and since *knowledge of results* usually is thought to function as reward as well as information, many theorists have appropriated feedback as a form of reinforcement."

Although many training psychologists have tried to distinguish between different functions or roles of feedback, they have not tried to divorce the feedback concept from *knowledge of results* or from reinforcement. It is our purpose here to show that clear distinctions are possible and necessary. "One can make a valid distinction between the dynamic information provided by sensory feedback and static knowledge of success or failure given at the end of the task . . . .The general rule in training design is that dynamic feedback of performance is more effective than static *knowledge of results* at the end of a task or motion sequence." The distinction between dynamic feedback and static knowledge of results becomes crucial when one attempts to study the efforts of introducing delay before providing the information.

Ammons (1956, quoted in Smith and Smith, 1965) proposed the general rule that "the longer the delay in giving knowledge of performance, the less effect the given information has." He then reviewed studies that tend to show a gradual drop in human learning efficiency when knowledge of accuracy is withheld for periods of up to a fourth of a minute or so. Although Ammons concluded that "the learner may not be able to use information given more than 15 or 20 seconds after the response," the ambiguous situation with respect to delayed static *knowledge of results* contrasts markedly with the situation with respect to delayed dynamic feedback. Delaying the dynamic sensory feedback performance by even a small fraction of a second seriously disrupts the patterning of motion and degrades its accuracy. This effect has been demonstrated many times by experimentally delaying the auditory feedback of speech and other of studies of delayed visual feedback.

The marked disturbances caused by feedback delays of a few milliseconds are clearly different from the impediment that may or may not result when static knowledge of performance is delayed by some seconds. The difference indicates that when we are dealing with two different classes of phenomena which should not be confused by lumping together the feedback and *knowledge of results* in a single category. "Although we think it important to distinguish between dynamic sensory feedback and static *knowledge of results*, we also recognize valid similarities between the two types of knowledge. Either can serve to inform the individual about the accuracy of his movements. When a particular response provides no intrinsic feedback signal, it often is critically important to give knowledge of accuracy in the form of an extrinsic signal at the end of the response. Verbal and symbolic learning often must be guided or defined in terms of static extrinsic knowledge until the individual has established intrinsic standards by means of which to monitor the learned responses. As the individual's body of symbolic knowledge grows and becomes better organized, he is able to monitor more and more of his own symbolic responses in terms of his intrinsic standards of accuracy, logic and consistency. Thus, an extrinsic signal (such as, That's right! or Correct!) may serve only to confirm a response that already has been monitored intrinsically.

Inasmuch as the term feedback is used widely to refer to all kinds of *knowledge of results*, we see no reason not to conform to the practice, even though there is some possibility of confusion. In general, we shall speak of the immediate sensory processes resulting from responses as *dynamic sensory feedback*, and terminal knowledge of results as *knowledge feedback*. It should be noted that some types of performance (such as tool using) involve several kinds of feedback effects, some of which are not easily classified in terms of dynamic feedback — knowledge feedback categories. However, all feedback effects have this important characteristic in common — they are related systematically to the reference response. In this sense, feedback differs from reinforcement, which needs bear no relationship to the response it reinforces. Rather, a reinforcement is related to the drive it reduces or the motive which it satisfies. "In our opinion this confusion of the experimentally demonstrated processes of sensory feedback control with what the learning theorists call reinforcement has had a stultifying effect on training science as well as on other areas of behavior theory. It is impossible to clarify the meaning of cybernetic control of behavior in terms of fuzzy concepts about the effect of rewards and punishments, or reinforcement. Real and important decisions can be made between the cybernetic control and the type of control that is achieved experimentally by manipulating extrinsic rewards, and fundamental differences exist between dynamic sensory-feedback stimuli and reinforcers. It is high time that psychologists started clarifying these differences instead of continuing to obscure them." (Smith and Smith, p. 208)

Evidence: Gropper and Kress (1965) state that in using television to "group-pace" programmed materials the latency of feedback was "not as critical as commonly believed." They found that two rates of pacing were sufficient to accommodate the requirements of individualization for a relatively heterogeneous group.

Greenhill, in Reid and MacLennan (1967) states "There have been efforts to provide various methods of feedback to the instructor and/or learner in learning situations where extensive use is being made of television films.

"Some studies have involved the use of two-way communication systems in conjunction with closed circuit television. Others have included the presentation of questions at the end of a television program or film showing with provision of correct answers to the learner, and knowledge of level of performance to the teacher who can then supplement the material provided by the film or the television lesson.

"Immediate knowledge of results on tests appears to increase learning, but there are not enough studies of the use of electronic feedback and classroom communicator systems to be able to note any consistent trend in results.

"It is suggested, however, that for such feedback systems to be effective, every student must respond to questions, respond to them frequently, and receive immediate knowledge of results. An alternative way of providing for such interaction between learners and stimulus materials is to program questions and knowledge of results into the films or television lessons themselves.

"One very encouraging recent trend is the incorporation of some of the techniques of programmed learning into television programs. This involves the inclusion of questions or short problems for students to solve, followed immediately by knowledge of results. Such an arrangement provides for active audience participation, with immediate reinforcement."

2.1f: Instructional strategy is concerned with ways of presenting content in instruction, i.e., the nature and sequence of events in the learning experience. Media have provided a vehicle to systematically vary type, quantity, and sequence of events in order to collect data on such unresolved issues as: the effectiveness of inductive and deductive procedures for various types of objectives and learners; the relationship between rules and examples; the use of complete or incomplete rules and examples; the appropriate time to employ programmed, directed discovery, and discovery techniques; the whole-part, large-small, bit-or-natural unit of instruction and a variety of stimuli required to maintain interest whether the learning be in the cognitive, affective, or psycho-motor domains. Unquestionably, many of the issues are very complex and strategy appropriate for a given objective, a given situational context, and a learner of given characteristics will be inappropriate if any single interacting variable is modified. Yet the strategy issues must be faced and the guiding principles must be developed to avoid what Travers called "the impossible alternative."

Evidence: Twelker (1964) used a task in cryptography to assess the effectiveness of various teaching strategies. More specifically, he wanted to test the effectiveness of various methods in teaching secondary school students to solve cryptograms, which required the students to substitute some of the letters in an encoded sentence for other letters in the alphabet according to some systematic rule.

The various teaching strategies used in the experiment were derived from earlier research. Programs based on B. F. Skinner's theories suggested that students should be given complete rules and complete example sequences. (Rules were defined as abstractions and principles, while examples were defined as instances or special cases of these principles.) However, other studies had shown consistently that transfer of learning was more effective when students were given complete rules and *incomplete* examples, than either not giving them rules or giving rules and specific examples. *Incomplete examples meant that the learner* was required to complete an example or solve a specific problem.

Twelker designed an experiment involving four different kinds of learning experiences to teach students to decode messages. In one type of experience both answers and rules were given. In another, answers were given but the learner was required to solve for rule. In another the rules were given but the student had to solve examples. And finally, there was one experience where neither the rules nor examples were complete and students were required to solve for each.

In the experiment, 235 secondary school students were assigned at random to one of five groups. One group was assigned to each kind of learning experience and one group (a control group) had no teaching at all but were only given the criterion test to determine whether they could transfer to examples and rules not given in the lesson.

Twelker found that there were no significant differences in performance on the criterion test among any of the taught groups. But he found that the control group which received no teaching at all scored highest on the criterion test. He stated "When the transfer test involved a new set of rules it was shown that *every* group performed poorer than the control group that received no training."

2.1g: This topic has proved to be a difficult area to research. "Large or small steps" at one time constituted a popular research area in programmed instruction, but definitions and findings were inconsistent. An attempt was made to identify and teach whole or "natural" units as contrasted to "parts" of the unit. While most of the divisions have certain elements of subjectivity to them, at the present time there is no principle to make clearer the requirements for appropriate instruction or instructional procedures aimed at modifying various kinds of behavior.

On the issue of optimal length of demonstration and practice segments, Smith and Smith (1966) state "There are no generally valid statements that can be made about the sequencing of practice, that is, about the relative effectiveness of distributed versus mass practice or of part versus whole learning. This statement is amply born out by research on optimal sequencing procedures in instructional film. A series of studies reviewed by Lumsdaine (1961) leads to no definite conclusion except that each kind of training presents its own special problems."

In teaching a complex motor-assembly sequence by means of a demonstration film, it was found to be more effective to intersperse practice periods after each *natural* demonstration unit. On the other hand, in teaching a geometric construction task by means of a film, it was found that breaking into the film for practice after a small demonstration segments gave good results during training, but led to relatively poor test performance. Another study attempted to determine whether it is more advantageous to demonstrate and practice each unit of a serial assembly twice before proceeding to the next unit or to demonstrate and practice each unit once and then repeat the entire sequence. In a task with three parts, the first method was better both in practice and on the final test, but in a test with four parts the first test was superior in practice but not in the final test. Other studies have indicated that *massed* review at the end of a film would be better than *spaced* review interspersed throughout.

Lumsdaine's conclusion was that sequencing of instructional materials with practice and review must depend, in part, on the inherent organizational features of the particular task. Similarly, Naylor and Briggs (1963) concluded that all the whole training methods should be superior to part methods for highly integrated tasks at all levels of complexity, and increasing complexity for relatively unorganized tasks will result in the part-task schedule becoming superior to whole methods.

Evidence: Smith (1965) devised an experiment utilizing individual frames, sequences, and the whole unit. He found that on immediate tests of retention, the feedback after each frame was significantly better than feedback after either a "sequence" or a "whole" unit. However, on a delayed test (3 weeks later) differences were not found to be significant. The "sequence" method was reported superior to the "frame" method in facilitating retention of information.

Smith and Smith (1966) state "Most linear programmers have agreed that each step in a program should be *small* enough to ensure correct response. Step size is usually defined in terms of difficulty, rather than in terms of the amount of informational material given in a frame. Thus, research on step size usually varies the size by increasing and decreasing the number of frames used to cover a given unit of material. A small step is easily taken where a larger step is more difficult because some of the intermediate steps have been eliminated.

Research on step size to find a step difficulty usually has favored small steps over large in terms of posttest criteria, although large step programs take less time. However, a recent experiment of Smith and Moore (1962), varied step size and pictorial cues in the spelling program. No difference was found in learning achievement related to step size and the large step method saved time. The authors report that very small steps and over-cuing may produce disinterest.

Since it would seem that less intelligent students might need smaller steps than bright students, Shay (1961) attempted to study the relationship of intelligence to step size and programing. This statistical analysis revealed no such relationship and his data suggested that small steps produce more learning at all ability levels.

Principles of learning economy including short practice sessions as opposed to massed practice, and whole over part learning, are valid in some situations but do not always hold, especially in complex tasks.

2.1h: Smith and Smith (1966) report "it was assumed by many that color, movement, realism, and so forth in visual materials would increase their teaching effectiveness when compared with black and white, non-moving, unrealistic portrayal. As a matter of fact, children usually prefer materials that are colored, contain action, and tell an organized story, but they do not necessarily learn more from them. Special features apparently aid learning only if they aid important discrimination, promote understanding, or increase the probability that the learner will make correct responses. Color improves the effectiveness of training film when color cues aid discrimination of significant parts of confusing material, but otherwise a technically inferior black-and-white version may be just as effective in teaching factual knowledge and promoting understanding of the subject matter as a finished colored version of a film."

Evidence: (May and Lumsdaine, 1958; VanderMeer, 1954) A film prepared in dramatic form with live dialogue was no better than one in which the same material was described in off-stage narration. For recognition of material, photographs and shaded drawings were poorer than cartoon type drawing, although better than line drawings. (Ryan and Swartz, 1956) Adding embellishments, music and humorous drawings to a film may actually decrease its teaching effectiveness.

2.1i: Smith (1967) states a series of studies carried out by the American Institute for Research by Briggs, Goldbeck and their associates have produced results showing that the relative advantages of overt, covert and reading responses vary with a number of factors, including level of difficulty. (Briggs, et al., 1962; Goldbeck and Campbell, 1962) In one study, low difficulty items were learned best by the reading group and covert responders, whereas items of intermediate difficulty were learned best by the overt responders. For a high-difficulty program there was little difference among groups. However, when test scores were divided by learning time to obtain learning efficiency scores, it was found that reading was most efficient and overt responses least efficient at all levels of difficulty. In another study in which only one program was used, the reading group again was fastest and did significantly better in a retention test after ten weeks. In this delayed test, the overt response group was slightly superior only in those test items which contained stimulus and response items that were identical or highly similar to those used in the learning program. This indicates that requiring the subjects to construct specific responses may actually have interfered with their learning of other relevant material. The authors of this report speculated that constructing a response and then seeing the confirmation may have created a *closure* effect which was absent from members of the reading group.

Evidence: Smith (1966) states "In an effort to equate the time factor for groups using different response modes Briggs, *et al*. (1962) compared four groups, all of whom studied for two hours. One group had eight pages of mimeographed text and the second had an overview of the topics followed by the text, with each page of text followed by a summary outline page. The third and fourth groups had Skinner-type programs; one group responded with the first letter of each word while the last group wrote complete responses. As each subject finished his assigned material he was given multiple-choice review questions on chemical paper to confirm the correct responses, but one third of the original material, varying by subject, was not covered by review. It was found that learning without review did not vary for the different groups, but learning with review favored the text-plus-review group. Again the overt-response groups were superior only in answering those test questions which were the same as program items. Many of the errors made by these groups resulted from applying responses learned in the constructed-response programs to the wrong test questions.

"Among the most significant results of this study were findings testifying to the value of the multiple-choice review questions. It was found that these questions produced highly significant increases in scores on test items having answers that were the same as the correct answers in the response portion of the multiple-choice question. Furthermore, the amount of increased learning due to review ranks perfectly among groups with the amount of time available to each group for review. Review also enhanced learning of information which appeared in the stimulus portion of the multiple-choice questions as well as in the response choices. In contrast, results indicate that information to be taught by constructed-response program frames must be assigned to the response portion of the frame.

"In general, active participation during film showings aids learning, but covert participation may be just as beneficial as overt. Audiovisual materials should be designed to elicit the desired responses, either overtly or covertly. Knowledge of results is accepted universally as a positive aid in learning. It is usually interpreted as a motivational factor but it is a more generally valid principle if it is understood as directive and corrective feedback. Results of experiments by Hovland, Lumsdaine, and Sheffield on active and passive group participation showed consistent superiority of the active over the passive group at various criteria of recall promptness in oral tests on the learning of phonetic alphabet at the completion of training. The data showed that differences in favor of the active response and feedback group appeared to be least when least needed and most when most needed—that is, mean differences were greatest for less motivated, slower students in learning in the more difficult portions of the material, and least for brighter, highly motivated students in learning the easier portions of the material.

The term "covert response" is used here to designate response acts which, unlike the implicit responding to a text or lecture, are deliberately made as explicit answers to a question or other express invitation for response, but which are not performed overtly. Such responses may serve as effective symbolic practices, but afford a less clear basis for differential feedback from an instructional program than can be occasioned by overt responses (Lumsdaine, 1965). One of the most interesting of several other experiments which have studied covert responding was performed by McGuire (1955b; 1961a), who used two rates of presentation. Subjects were given six practice trials in naming mechanical parts that were displayed and named in six presentation trials. The latter lasted two seconds per trial per each part in the fast condition, four seconds per each in the slow condition. Time for the *practice* trials was constant for all subjects. Overt-responding subjects wrote the names of the parts; covert-responding subjects merely named them mentally. The interesting finding was that, despite the lack of any significant difference for the two forms of responding at the slower rate, *covert* responding was significantly better at faster rate. One interpretation of these results is that if instruction has not adequately prepared the learner to respond correctly, forced overt responding may lead to distracting anxiety, to the practicing of errors, or both.

"Active participation by the learner, including an advantageous learning set, facilitates learning. However, active participation does not necessarily mean overt participation."

2.1j: Special embellishments of films and graphics apparently do not increase learning unless they aid specifically in making important discriminations or in promoting understanding. The devices that call attention to important points apparently aid learning of those specific points.

Evidence: Studies by Wulf and Kimble (1953; 1961) on partial prompting (response guidance to control errors in practice) used a combination of film strips and workbooks to teach the reading of slide rule skills. Students were given a practice schedule that alternated short segments of audiovisual exposition and demonstration with practice exercise in workbooks in which slide rule scales were reproduced. All groups were given the same exposition and the same amount of practice.

The main experimental variable was the use of various forms of prompts. For example, when asked to locate a particular scale value, the prompted group was provided the constraint cues which limited the possible responses, but without specifying the correct answer. The no-guidance group was allowed to make more effort by withholding such prompts. In all cases the students had already been told how to do similar exercises. The results show a clear margin of superiority for the subjects of the prompted group. They did better on a later test not only on the items to help the students to avoid certain types of errors which preliminary work had shown were the ones most commonly used.

2.1k: Travers (1966, p. 124) found that "where the testing condition was in the same modality as the learning presentation the mean learning per trial was higher than where learning was done in one modality and testing in another."

Inquiry and Reconstruction in the Behavioral Sciences

Jack Crawford

Focus

A favorite pastime of graduate students a generation ago was to argue the question, "Is ___ really a science?" Into the blank any of the fields such as Sociology, Psychology, Anthropology, etc. could be inserted. Rousing discussions ensued, and the flow of ideas was often brilliant and as endless as the correlated succession of pitchers.

But the issue was never taken up very seriously by investigators in the questioned areas. They continued to explore and evaluate, to build schema and make applications. The various fields in question have proliferated enormously and now constitute a substantial portion of our cultural heritage. The old argument appears inappropriate. It is doubtful if even a mild college protest could now be aroused on the issue.

The purpose of this chapter is not to revive the form of bygone discussion (unfortunately I no longer have the constitutional prerequisites), but to examine some distinguishing features of these areas, now known as the Behavioral Sciences.

The object of such examination is to provide the reader an option of perspectives from which he can perceive and interact, with the ramifications of those burgeoning areas under discussion. Three general perspectives will be sketched. They are not meant to be contradictory but, on the contrary, somewhat supportive.

The inquiry processes used in the behavioral sciences will be examined in the major portion of the chapter. These investigative moves will be compared with the conceptual edifices the fields have erected. The aim of the first section is analogous to comparing the procedures of pilot and navigator with flight plans and reports.

A supporting section presents some points of controversy. Rumors of family disagreements within the behavioral sciences will be aired. Asserted limitations of the behavioral sciences will be examined. These will include limitations maintained by scientists, non-scientists, and anti-scientists. Sensitive points at which the behavioral sciences interface with other fields will be reviewed briefly. This section may be compared to a limited clinical examination stemming from complaints about the patient as well as from him.

Finally, a brief third section consists of a conceptual etiquette manual for the layman who needs to interact with the behavioral scientist or his writings. The section outlines a series of moves designed for a productive interchange. It may be compared to a guide for a native who was about to walk unarmed into the fort trading post.

A proposed role for an instructional technologist has been suggested in the previous chapters. As described, the role suggests three acts in which the technologist player must interact with a behavioral scientist. Such interaction is required by instructional problems in which:

1. The content of the proposed instructional system is in fact some behavioral science area;

2. Although not the entire content, the behavioral sciences are a supporting component, e.g., literature or history content is placed in a sociological perspective;

3. Insights or approaches derived from the behavioral sciences are used to develop the instructional system.

Interaction with a live behavioral scientist may be required, but is not always necessary. Wholly live ones, in fact, are rare; most scientists show signs of atrophy in all but a narrow speciality. The interaction instead may be publications. Or, the technologist player may have so steeped himself in some area of science that for the required purpose he can play a dual role. The important requirement for the technologist player is to make the interaction as productive as possible.

A somewhat similar problem is faced by professional negotiations, interrogators, and infiltrators. Successful chaps (sampled from the living) in these fields agree upon the cardinal importance of: First, UNDERSTAND THE GAME THE OTHER FELLOW IS PLAYING. Towards this end, let us examine the science game as the behavioral scientist plays it, or thinks he plays it. Afterwards, possible strategies for the informed technologist player may be developed.

The name of the game is the scientific method. Myths and legends about the game are part of our cultural heritage and are perpetuated by educational institutions to instill proper respect in the young. One of the more accepted myths of the present era is the existence of the scientific method The myth typically follows a sequence of this sort: through patient and close observation the scientist arrives at a set of postulates (substitute generalizations or hypotheses if desired). Then, by careful logic he deduces observable consequences from these. He then designs an experiment to test whether the consequences do indeed appear. From results of the experiment he either confirms or rejects his postulates, revising them where required, and repeats the cycle.

The myth is plausible and frequently presented to college freshmen by colorful and impressive films, and less colorful lectures. The sequence of steps are readily stored and regurgitated intact at exams. Despite its obvious mnemonic advantages, certain objections to the myth should be noted:

1. It is false.

2. The falsity leads to a constriction of the imagination and possibly to erecting an artificial canon limiting new inquiry.

3. It confuses the process of scientific inquiry with a reconstituted product.

This myth represents one idealized form of how science proceeds. It is not the only possible form. Other idealized forms include the model and the inductive generalization. In the former, a physical or mathematical system is applied as the basis for studies. The model is not necessarily altered because of ensuing data. It may or may not be of particular usefulness in any given real setting. Completed reports of mathematical models of behavior appear to fit this version of science. Presumably, the models were constructed through logical considerations only; almost, if not completely, insulated from data. Marsyk and Ratoosh (1965) review a number of such models.

An alternative ideal presents a picture of a scientific Detective Friday seeking "Just the facts, Ma'am. Nothing but the facts." This image of the scientist suggests he uncovers the laws of nature solely by careful observation.

A colleague of mine used to assert that his work was not to be subjected to arguments about the implications of the approach or even evaluated as one of several alternatives, because his work consisted of reporting summaries of the facts of behavior with no preconceptions. Within the behavioral sciences, a preoccupation with operant conditioning techniques appears to promote this version of the myth.

However, the presence of other myths is of only tangential relevance to whether the working processes of science as it proceeds are fairly pictured by the prevalent deductive myth. I flatly submit they are not—at least in the behavioral sciences. At no time have I ever observed a colleague in the hot pursuit of research following the model. Sometimes the final reports of the study, at least about the third draft stage, begin to exhibit resemblances. But this is another matter. Observations of others tends to confirm the notion of divergent approaches, none of which fit the myth.

Whatever the value of the myth, as inspiration or introduction, it tends to erect a fraudulent standard of scientific respectability. The two glaring weaknesses of most descriptions of *the scientific method* are:

1. A preoccupation with one rather than a number of alternative strategies of inquiry and verification.

2. A tendency to brush lightly over the initial focusing on a problem, and the question-hypothesis generating portions of any strategy.

With regard to the latter weakness, it is like an account of wilderness survival which begins, "Take a freshly caught salmon and cover it with wet clay..." How are we to discover and capture the salmon?

Listen to Fred Skinner's account. Dr. Skinner is not only one of the most renowned of behavioral scientists, but he tells clever yarns which often turn out to be too true for comfort.

> ...it is a mistake to identify scientific practice with the formalized constructions of statistics and scientific method. These disciplines have their place, but it does not coincide with the place of scientific research. They offer *a* method of science but not, as is so often implied, *the* method. As formal disciplines they arose very late in the history of science, and most of the facts of science have been discovered without their aid. It takes a great deal of skill to fit Faraday with his wires and magnets into the picture which statistics gives us of scientific thinking. And most current scientific practice would be equally refractory, especially in the important initial stages. It is no wonder that the laboratory scientist is puzzled and often dismayed when he discovers how his behavior has been reconstructed in the formal analyses of scientific method. He is likely to protest that this is not at all a fair representation of what he does....My doctoral thesis was in part an operational analysis of Sherrington's synapse, in which behavioral laws were substituted for supposed states of the central nervous system...It is not surprising that my first gadget was a silent release box, operated by compressed air and designed to eliminate disturbances when introducing a rat into an apparatus. I used this first in studying the way a rat adapted to a novel stimulus. I built a soundproofed box containing a specially structured space. A rat was released, pneumatically, at the far end of a darkened tunnel from which it emerged in exploratory fashion into a well-lighted area. To accentuate its

progress and to facilitate recording, the tunnel was placed at the top of a flight of steps, something like a functional Parthenon...The major result of this experiment was that some of my rats had babies....Here was a first principle not formally recognized by scientific methodologists: when you run into something interesting, drop everything else and study it. I tore up the Parthenon and started over....Now for a second unformalized principle of scientific practice: some ways of doing research are easier than others. I got tired of carrying the rat back to the other end of the runway. A back alley was therefore added....The experimenter...could collect records from the kymograph...in comfort....A third unformalized principle of scientific practice: some people are lucky. The disc of wood from which I had fashioned the foot magazine was taken from a storeroom of discarded apparatus. It happened to have a central spindle, which fortunately I had not bothered to cut off. One day it occurred to me that if I wound a string around the spindle and allowed it to unwind as the magazine was emptied...I would get a different kind of record. Instead of a mere report of the up-and-down movement of the runway, as a series of pips as in a polygraph, I would get a *curve*. And I knew that science made great use of curves....Psychologists have adopted cumulative curves only very slowly, but I think it is fair to say that they have become an indispensable tool for certain purposes of analysis....Now, as soon as you begin to complicate an apparatus, you necessarily invoke a fourth principle of scientific practice: apparatus sometimes breaks down. I had only to wait for the food magazine to jam to get an extinction curve. At first I treated this as a defect and hastened to remedy the difficulty. But eventually, of course, I deliberately disconnected the magazine....Foolproof apparatus is no doubt highly desirable, but Charles Ferster and I in recently reviewing the data from a five-year program of research found many occasions to congratulate ourselves on the fallibility of relays and vacuum tubes....This account of my scientific behavior up to the point at which I published my results in a book called *The Behavior of Organisms* is as exact in letter and spirit as I can now make it. The notes, data, and publications which I have examined do not show that I ever behaved in the manner of Man Thinking as described by John Stuart Mill or John Dewey or as in reconstructions of scientific behavior by other philosophers of science. I never faced a Problem which was more than the eternal problem of finding order. I never attacked a problem by constructing a Hypothe-

> sis. I never deduced Theorems or submitted them to Experimental Check. So far as I can see, I had no preconceived Model of behavior—certainly not a physiological or mentalistic one, and I believe, not a conceptual one... Of course, I was working on a basic Assumption—that there was order in behavior if I could only discover it—but such an assumption is not to be confused with the hypotheses of deductive theory.

It may be useful to distinguish three ways of closing in upon a problem, *before* attempting to resolve it.

> 1. A deliberate search for the problem, looking for gaps, contradictions, new extensions and possible implications of accepted knowledge. This approach can be described logically and fits our accepted reporting formats.
>
> 2. Messing around with inquiry on your mind. A much looser approach than number 1. A series of iterative explorations, each step highly dependent upon the outcome of the previous step.
>
> 3. Serendipity. Blundering onto something—while involved in another activity. Different from the flexible teasing out implied by number 2. Here the problem reaches out and hits you as you are trying to walk by.
>
> One example was the discovery by Olds of "pleasure centers" in the brain. Olds was engaged in exploring the reticular system, a diffuse network of nervous tissue involved in the alert-quiescent dimension of behavior. He implanted an electrode by accident in the septal area of the brain, and found that the subject would work enormously for a few millivolts of stimulation. A jolt of electricity in this area literally turns one on. There is some evidence that this is preferred over food, drink, or sex.

Sometimes this closing in to the problem serves to clarify the prospective solution. For example, if the problem has specifically narrowed to a question of "if A, then B?" the need for some confirmation or refutation begins to shape the direction of inquiry. The context of discovery becomes quickly enveloped by the context of confirmation.

However, the routes to potential solutions are frequently more indirect. The creative solutions to scientific problems here appeared. Afterwards the scientist has attempted to re-construct the events. There are some recurrent themes in these accounts. A classic is the account of Frederick von Kekule, who developed the crucial molecular ring concept.

> I turned my chair to the fire and dozed, he relates. Again the atoms were gambolling before my eyes. This time the smaller groups kept modestly in the background. My mental eye rendered more acute by repeated visions of this kind, could now distinguish larger structures, of manifold conformation; long rows, sometimes more closely fitted together; all twining and twisting in snakelike motion. But look! What was that? One of the snakes had seized hold of its own tail, and the form whirled mockingly before my eyes. As if by a flash of lightning I awoke...Let us learn to dream, gentlemen.

The use of analogies echoes throughout most of such accounts.

> The great biologist Elie Mechnikoff felt rather lonely one afternoon in 1890 'when the whole family had gone to the circus to see some extraordinary performing apes, and I remained alone with my microscope.' The microscope was in a laboratory of the Ecole Normale which Pasteur had given him; Mechnikoff was observing the life of the mobile cells in the transparent larvae of starfish, and idly threw a few rose-thorns among them. The thorns were promptly surrounded by the larvae and dissolved inside their transparent bodies—they had been gobbled up and digested. This reminded him of what happens when a human finger is infected by a splinter: it will be surrounded by pus which, like the starfish larvae, will attack and try to digest the intruder. By this analogy Mechnikoff discovered the organisms' main defense mechanism against invading microbes: the 'phagocytes', cell-eaters, a population of mobile cells among the white blood corpuscles.
>
> The starting point of Kepler's discoveries was a supposed analogy between the role of the Father in the Trinity and the role of the Sun in the Universe. Lord Kelvin hit on the idea of the mirror galvanometer when he noticed a reflection of light on his monocle. Sultan saw that a branch was like a stick; Newton saw that the moon behaved like an apple. Pasteur saw the analogy between a spoilt culture and a cow-pox vaccine; Fleming saw the analogy between the action of a mould and the action of a drip from his nose. Freud, on his own account, conceived the idea of the sublimation of instincts by looking at

> a funny cartoon in the *Fliegende Blatter* — the one-time German equivalent of *Punch*. In the first picture a little girl was herding a flock of goslings with a stick. In the second she had grown into a governess herding a flock of young ladies with a parasol.

Other themes appear. One of the best summaries is found in Hadamard (1949). However, recollections are notoriously poor evidence, even recollections about discovery. A more verifiable stream of knowledge about discovery now stems from certain areas within the behavioral sciences themselves. A growing number of useful strategies of discovery—often termed heuristics—have been identified. They do not insure solutions, but enhance the likelihood of finding one. Readable accounts of these are given in Johnson (1955), Taylor (1963), and Kleinmutz (1966). That they can be rendered into explicit and precise steps is best exemplified by the computer simulation work of Newell, Shaw, and Simon (1962). They were able to teach certain heuristics to a digital computer (this form of teaching is called programming). The computer was then able to use the heuristics to solve such problems as playing chess, designing electrical motors, composing music, and discovering mathematical proofs.

I am not presenting a list of such heuristics in this chapter, although they are a fascinating topic in themselves. Some of those for which we have evidence are probably used by successful scientists, along with unknown procedures of discovery. Both formal training and accepted standards of scientific reporting tend to bypass them. Few scientists are able to discuss their own discovery processes fluently, as for example they might readily discuss a given discovery, the product of such processes, or their efforts at evaluating it. The important point is that a large portion of any working scientist's effort is likely to be taken up with "trying to come up with something worth investigating."At this point, it may be sufficient that the technologist player recognize the crucial nature of such processes, that they tend to be obscure, and that regular channels of communication about them may not be readily available to the scientist.

Now to a portion of the scientific method that comes through loud and clear in everybody's version. A hallmark of the scientific pursuit is the quest for *verifiable* knowledge. The knowledge may (or may not) be true. But the vital concern is with how we can presume it to be true. The concern is translated into a set of methods by which the knowledge claimed may be verified--confirmed or infirmed. Thus, any asserted knowledge about the behavior of man is, in a *science* of behavior, put to tests of verification. These essentially are confrontations. The alleged knowledge is confronted with other statements—statements of observations, or statements of theory somehow related to observations. In the behavioral sciences, claims of knowledge about behavior lead, directly or indirectly, to assertions about some observable aspects of behavior. The verification consists of confronting the claim with a statement derived from the observation.

All claims are continually confronted by evidence. One of the ground rules of the scientific community is that everyone is encouraged to bring in evidence relevant to an assertion. Professional journals, of which there are literally hundreds in the behavioral sciences, are largely composed of such accounts. Standards for acceptable observations are usually quite high. However, any scientist may depend upon the lusty support of his colleagues, across the nation and sometimes internationally, to confront his ideas with a host of relevant observation statements, often more than he ever wanted.

The commitment to verification leads to two kinds of observational searching. First, a search for the consequences of the idea. Usually an implication of what we might expect to observe if the idea in question were true.

The second kind of search is even more crucial if the idea is to achieve status as a scientific contender. This is a search of that evidence which would cast doubt upon, or even refute the idea. Some ideas look good, but like some good looking women, they will embrace everything and anything. They are too loose to meet the verifiability criterion, although possibly serving other good purposes in the culture. If no conceivable outcome will cast doubt upon an idea, the idea must be removed from scientific employment. Some hoary explanations of human motivation belong here. "Men do what gives them pleasure." Examples of people subjecting themselves to all sorts of abuse are handled by asserting that the abused really get pleasure out of their pain. No conceivable outcome can unseat this assertion. Just what, if any, useful disposition can be made of such ideas will be discussed later.

Sloppy ideas are difficult to refute or confirm. This is one reason why many ancient, common sense notions live on. They are so loosely framed they encompass almost any outcome. By contrast, precise ideas are readily faced with possible discrepancy.

Relationships in a precise equation have been alleged as holding between the intensity of our sensations and the intensity of a corresponding physical event such as a sound or light source. To the degree that the asserted relationship suggests a given exponential or logarithmic form, deviations from the asserted relation are easily conceived and detected from observed records.

To derive the empirical statement which may confirm or inform a scientific idea (let us now call the idea a hypothesis) is ordinarily a complex series of moves. One reason for the complexity is that scientific hypotheses are general while the source of confrontation stems from *singular* factual statements.

Further sources of complexity derive from the need to determine:

(1) the meaning of terms as they are translated to observation;
(2) how observation shall be arrayed;
(3) which of all possible individuals or events shall be observed;
(4) just what aspect shall be noted and how;
(5) how to analyze and interpret our record of the observations so that the record bears upon the hypothesis.

The strategic intricacies involved in dealing with such questions form the basis of experimental design, measurement, sampling, and data analysis, topics in which complicated procedures have been developed for the behavioral sciences. Such procedures often possess mathematical garb, (and sometimes substance) giving them a formidable countenance to the onlooker. However, the questions they are designed to shed light upon are relatively straightforward and can usually be expressed in a natural language without serious loss.

A large share of the scientific enterprise consists in planning and conducting such empirical confrontations. However, a related but differing confrontation also assumes importance. Each idea must make some kind of fit within a bed of other current ideas. This cognitive bedding will lie both in the particular area of concern and to some degree within the general notions of the discipline and across disciplines. If the idea is part of an organized theory it is supported or submerged by the rest of the theory. Furthermore, the interface with other theories will bear upon its support. A burden is placed on the newcomer to either find consistency with those most firmly established components in the body of knowledge or revise or supplant them.

A reconstruction of the version of science we have been describing may be schematized as in Figure 1. Two points should be noted:

1. The processes involved in each step, e.g., identifying a problem, arriving at an hypothesis, may be any of a number of kinds.

2. The *result of any cycle of the procedures gives rise to further questions and problems which require similar searching.*

The second point bears emphasis. No permanent solution leading to quiescent satisfaction seems to appear. *The better efforts give closer approximations than were previously available, but also uncover more questions, unknown possibilities, or newly perceived gaps.*

The above summary is presented as a starting point. It, too, is an oversimplification, subject to the same class of criticisms leveled earlier at other summaries. But perhaps we can purge it by a guided tour through some critical components of the scientific enterprise.

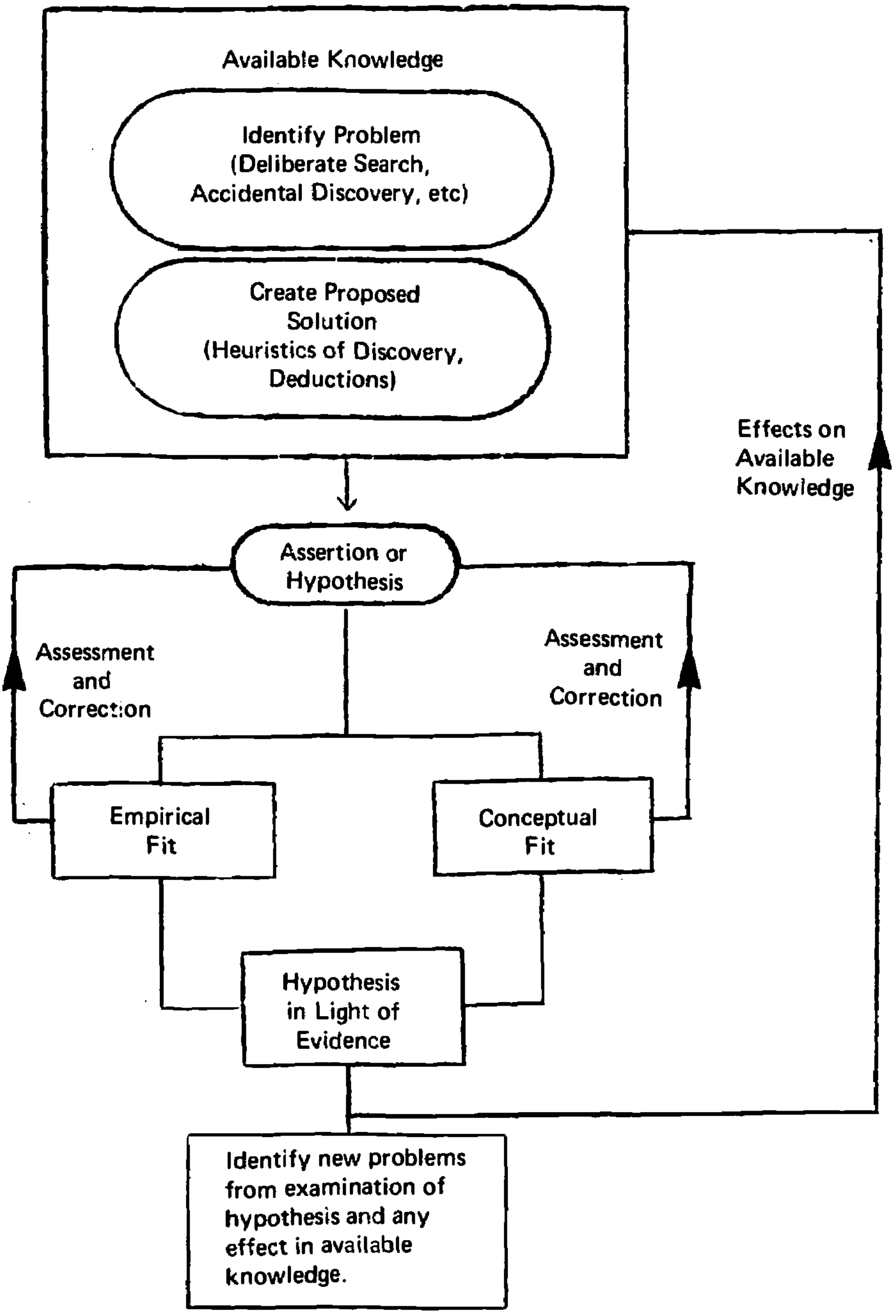


Figure 1. Scientific Method: An idealized flow abstracted from an indefinite series.

CONCEPTS

The prime elements in any effort at scientific explanation or descriptions (or non-scientific for that matter) are concepts. The term "concepts" refers to the classes or categories by which things and events are grouped and analyzed. Fire, earth, men, energy, learning, dying, and media institutes are concepts. The concepts we use determine to a large degree both the manner and the success of our attempts to carve the world into manageable, or understandable, chunks. An examination of the key concepts used by an individual, or a group, sheds a good deal of light upon the accomplishments and limitations of his approach.

In the behavioral sciences, concepts have not only developed somewhat independently in particular fields but have been subject to certain general influences. An examination of certain of these latter influences, somewhat common to all the behavioral sciences may aid in understanding not only the science but the scientist as well.

The fundamental demand upon scientific concepts is that they relate somehow to the world of observation. Not all sorts of fantasy are tolerable; they must allow observations to provide continual confrontations. Furthermore, the professional requirements of all the sciences demand a consensus of observations. You must, under similar conditions, be able to observe what I claim to have seen. This is a relatively gentle emphasis upon the need for experience.

A more strident emphasis has had marked influence in the behavioral sciences. This is *operationism*. The idea came from P. W. Bridgman, a physicist specializing in high-pressure phenomena. The notion is that to relate concepts to our actual observations calls for certain performances. We must measure in such and such a way; we must manipulate things in the laboratory in an exact fashion, etc. To use a concept means to follow certain operations. Therefore, what does the concept mean? It means the operations involved in its use. For example, what is meant by anxiety? Those operations used in measuring anxiety, including specification of the instrument used and the technique of administration. For several years, a clamor for operational definitions of every concept resounded through the ranks of behavioral scientists—and most loudly in the experimental psychology platoons. The clamor has subsided but some of the noise has remained as part of the background - mood-setting music. The operational emphasis did and does serve as a useful antidote to pretentious, flatulent concepts. A classic example is the concept of intelligence, pervasive and slippery. The operationist insists that we specify what is involved in giving and taking an intelligence test. And lo, that's what the hallowed, cloudy concept means. The insistence upon spelling out the steps in actual use or measurement has reduced many a global, armchair notion to mini-size. The difficulties that beset the operationist criterion of meaning are of two sorts: First, literally, no one could give a completely satisfactory operational definition. Either some detail of specification was lacking, or it could not be determined just when an operation was common and when it was different (and thus defining a new concept). Operational definitions can only be an attempt or approximation. Secondly, some concepts do not refer to observable events but, combined with *other* concepts and principles do reach out to observable consequences. But those operations take in more than the concept the translating chain of concepts are thus defined as well. Furthermore, the observed consequence is but *one* of a possible set. We have only partly grazed the meaning of the original. Much of the meaning may lie in its relations with other concepts and its fit with generalizations, both of these requiring translating chains to find their way into direct operations.

These limitations do not negate the usefulness of operational definitions as a first order and as a continuing reality check. It places a burden on the plaintiff to make his case. If the concept can't be translated into specified overt operations, then he must show cause.

Logical Positivism

A philosophic movement, closely related to operationism, stemmed from a group of European philosophers who became known as the Vienna Circle. The aim of the circle was to replace most if not all of philosophy by an examination of the logic of science. The group called attention to the distinction between *formal* and *empirical* statements. Formal statements are devoid of reference to a "real" world. They express only relationships among themselves. Mathematical systems are excellent examples. As formal statements, any application is irrelevant. Their logical and syntactical relationships are their only meaning. The formal is thus distinguished from an *empirical*. Empirical statements assert something about the world and can be verified by observation. A statement is either formal, empirical, or nonsense. A major programmatic goal of the Circle was to help make such distinctions, and assist science by exploring the syntactical meanings of its formal language. The group was introduced to America under the banner of "logical positivism" primarily by H. Feigl and G. Bergman. The impetus of the logical positivists fathered and nourished concerns with the logic and meaning of science. The movement so fit the growth of the behavioral sciences that its positive contributions are difficult to extricate. They have become woven into our garments.

Shorn of some of its extreme and infant claims, logical positivism has brought a legacy to the behavioral sciences of:

1. Both a realization of the need for and the development of

some logical tools by which to explore theoretical concepts and their implications.

2. An *emphasis upon verifiability* as a criterion for empirical concepts.

3. To some degree a freedom arising from the orientation that, if it is not possible to trace out the observable consequences of a notion or its logical relations to the concepts which do have observable consequences then dismiss it and proceed.

4. An abortive effort to unify the sciences by means of a common elemental language into which all assertions could be reduced. Despite scholarly fanfare, this effort, known as physicalism and the unified sciences, has never progressed beyond programmatic declarations of intent and claims that it is possible (and the first two or three volumes of a proposed encyclopedia).

Concepts and Theory

This relationship is often put as a paradox of the form "proper concepts are needed to formulate a good theory, but we need a good theory to arrive at the proper concepts." (Kaplan, 1964) The important concepts are groupings which allow more resemblances and relationships to be discovered. Concepts might be considered tentative taxonomies. As knowlege improves and/or theories become more powerful the concepts are revised. Revised concepts assist theory growth. The process is a series of approximations. The history of the behavioral sciences can be summarized by the conceptual fetters they have outgrown and the successive approximations in concept and theory they have devised and subjected to verification.

A Continuum: Observable-Theoretical

Some concepts do refer rather directly to observables. The application is relatively simple. Some overt evidence or action is evinced which we have little difficulty agreeing upon: "naming the parts," "holding the artifact," a "marked ballot," etc. Other concepts demand more inference between what is signified and what is observed; an emotion detected through skin conductance or blood pressure indicators; a concept inferred through yes-no discrimination. But other concepts are still more removed from observables. It may not be clear which observables determine the meaning although it is dependent somehow *in principle* on observables. And, the shift can continue to theoretical concepts whose meaning is inadequately given only by the embedding system, e.g., "Little rg," "electra complex," or "role expectancy." These demand examination of the entire related set of concepts in the theory—and are less susceptible to exploration by their observable referents.

Theoretical concepts are often brought into relation with observation by what are called "coordinating definitions"—*an example* of the translation of the concept. But one or a set of possible examples leaves others open as a remaining set (a point emphasized previously). The meaning specified leaves other meanings uncertain. This uncertainty may be with respect to the relationships between the concept and the whole body of theory for which new applications are possible. Furthermore, all concepts have a degree of openness. They are not water-tight. Openness may exist as to boundaries of the concept—just where its limits lie or, in reference to a typical or ideal instance. All theoretic concepts in the behavioral sciences are marked by some degree of such openness, or vagueness. The process of scientific inquiry is not simply a tightening up of looseness, but a campaign of tentative closures, explorations of ambiguity, and revisions of meaning. There is a continuous interaction between concepts, theory, observation, etc. The concepts are tools of inquiry. Watchmaker's tools are of little use in highway construction. Whether concepts are suitable depends on the task and our stage of progress. Rough tools are often the best for clearing a jungle. However, journeymen understand the differences between roughing-in and finishing tools.

LAWS

Concepts acquire power as they become incorporated in laws—that is, if the laws turn out to be true and useful. Laws acquire power as they become organized with other laws and incorporated into systemic theory (that is, if the theory turns out to be. . .). By power, an explanatory and predicting function is usually meant.

Laws are statements about relationships between concepts, e.g., cause-effect relationships, or how one concept may vary if one or more others change. The following are some examples, loosely phrased for convenient expression, of such statements:

> Extremely tenacious behavior is created by reinforcement schedules with variable intervals.
>
> Problems become more difficult to solve when they require the use of the familiar in an unfamiliar way.
>
> The day-to-day decisions of an organization tend to be taken as commitments and precedents and thus come to affect the character of the organization.
>
> from Berelson and Steiner (1964)

The term is ordinarily reserved for a generalization which is heavily supported by evidence. Most generalizations are candidates for laws. The term "hypothesis" emphasizes this nominee status. The concepts within such a generalization are referred to as "variables." As currently used, "variables" can mean any event, object, or attribute. The universe can be divided into variables, constants, and relations. Behavioral scientists don't seem to run across constants, so they focus on variables and the relations among variables. A statement of the sort, "this study was concerned with the following variables...", means that the study dealt with the following kinds of behavior or events.

Laws are the common meeting ground between scientific workers whose orientation is dominated by observation and those whose outlook is preoccupied by intricate theoretical networks which are related to observation only by complex translations. All salute the importance of laws, although they frequently disagree on their meaning and function.

Use of Laws

Laws represent the hoped for outcome of investigation. Tentative laws become rejected, revised, or established through inquiry. But, that is not the only function of laws. At least two other uses can be distinguished:

1. One of the more perplexing circularities is that general propositions of a lawlike form are involved in the basic identifications of objects and events. To identify that flux of sensory input as "a paranoid;" "it's Jack again;" "laughter," depends on singling out some enduring similarities over time, space. In this sense a general construct process is involved in perception.

Early studies of von Senden (1932) on adults who had acquired vision after being blind from birth found that recognition and identification by sight involved a difficult inferential process. Patients were counting bumps, reciting identifying features, and trying to make up simple rules to distinguish pictures of camels from fish, their wives from nurses, etc. Later and more careful research substantiates the complexity of what is often taken as a straightforward process —"perceiving what is out there."

2. Presuppositions are brought to every search. We can't treat every notion as a problem simultaneously. Generalizations about the subject area and about the instruments and techniques of observation are used as a starting point. We may later have to turn back and subject them to scrutiny. And, as

the presumed generalizations are revised, then return to further explore the original subject. And then....

Some Distinguishing Features of Laws

Laws tend to be regarded as more than statements that "happen to be the case." In this sense, scientific laws are often termed nomological, or nomic, generalizations. They are distinguished from other statements *of the same form*, but which lack the power of laws. An example of the latter is: "All the papers for this media institute contain logical contradictions and factual errors." Or, in more complete form, "For every x, if x is a paper in the Teaching Research media institute during the Spring of 1968, then the paper...." Is this a scientific law? Let us examine some possible criteria:[1]

1. The statement is restricted in time and in designated object. A suggested standard is that true laws are unrestricted by any specific spatiotemporal region. This is not wholly satisfactory, inasmuch as many accepted "laws," planetary motions for example, are difficult to frame in a completely unrestricted way.

2. The statement cannot be vacuously true only. "Every page of Schalock's chapter after page 376 is free from error" is true by the rules of log, but is unacceptable as a law. The statement can't be contradicted, so is true in this vacuous sense (at least, by last count he had halted at page 312, Supplement No. 11). The statement must relate to objects for which there is at least indirect evidential support.

3. Our candidate statement about the papers may be viewed as a conjunction of statements about the six papers. The evidence exhausts the scope of the statement, and there aren't more papers to be added (thankfully). A law must be broader than a set of evidence corroborating it. And the range of evidence cannot be closed to new arrivals.

4. Of course, the statement must be true. Evidence must somehow support it.

5. Finally, there is some basis for requiring that laws are supported not just by direct evidence but also by supporting laws, assumptions, etc., i.e., a theoretical net. A law which is

[1] Taken from Nagel (1961)

> so supported syntactically also derives support from other evidence of the system. This leads to remarkable viability. Such laws are not likely to be dismissed in the face of a little negative evidence. Don't be dismayed now — all laws are confronted by a proportion of what appears to be negative evidence.

A statement which is a general summary of observations, though cast in a form which encompasses more than a closed set (criterion 3), is more sensitive to negative instances. It can be dismissed or radically changed without widespread effect on the body of knowledge. Removal of a law tied in with many others may require complete reorganization. The tendency is to reinterpret the negative evidence. Errors of observation and measurement and the influence of confounding factors are often called upon. If necessary, a new concept, or qualifying statement, may be appended.

Kinds of Laws and Almost Laws

Quasi-laws. "The most interesting fact about laws of Nature is that they are virtually all known to be in error." Scriven (1961, p. 91) But we keep on using such laws, with or without the defensive adjustments mentioned above. The law continues to serve a useful purpose in the pursuit of knowledge, and it may well be th· best available tool. Until we can directly attack what is behind the exceptions, we'll use what is at hand. Laws in the behavioral sciences are pretty much of this sort. But it does not follow that they are useless, necessarily misleading, etc.

Taxonomic orders and laws. These are often an organized set of lists. They mark out concepts to be used. The presumption is that the taxonomy represents a useful way of slicing up and ordering the area. They are as useful as the attributes on which they are based. Taxonomies are only a rough starting point in early stages of inquiry. If useful laws are the basis for the classes then the taxonomy has power. Simply arranging a mess of worms in an array may give feelings of order to the arranger—and often nothing more. Too often they present a facade of knowledge that impedes further inquiry.

Two kinds of laws deserve special mention. They are the hallowed hallmarks of "real" science. And, they are the goals of a large proportion of inquiry in the behavioral sciences. These are the causal and functional relation types of laws.

Although the notion of cause has accrued a number of meanings throughout its use in diverse areas, its meaning in scientific enterprises can be fairly defined. Four conditions are required for a law to be nominated causal:

1. The cause/effect relationship is invariable, i.e., the cause is invariably followed by the effect.

2. The events involved in a cause/effect law are spatially contiguous. If they are at a distance there must be some basis for assuming a linking network of contiguous events between them.

3. The cause precedes the effect and they are temporarily contiguous. If separated in time, a linking chain of events must be assumed.

4. The events stand in an asymmetrical relation. The cause leads to the effect but not vice versa.

There are sticky problems involved in the notion of causal laws. Two of particular note are: the assumed spatial or temporal chains connecting the events; and the sufficient conditions for the relationship. The expressed cause is not usually sufficient. A number of boundary and supporting conditions must be present. The "cause" then completes the required set.

Laws of Functional Relation

Such laws assert a mutually dependent relation between the magnitudes of two or more events.

Notice that these do not suggest any required sequence, only that a change in one event or set is accompanied by a change in the other. Such laws have replaced causal laws in many areas of the physical sciences. In consequence a number of behavioral scientists feel that the attainment of such laws represents the ideal for behavioral sciences. Pursuit of such laws is established, although to date the number of laws satisfying the precision required of the functional relation *and* the evidential support in behavior is not large. But the number of prospective candidates (without much observable support) displays a growth rate comparable to that of prospective Republican candidates.

Statistical Laws

A statistical law asserts that a relation, or even an effect, is not invariable but that over enough trials a specified proportion of outcomes will occur.

Only a small proportion of laws in the behavioral sciences are stated in statistical form. On the other hand, our observations reveal that most of the evidence is on a probable footing. Most of the animals or people perform approximately as the law indicates. What is usually done is not to form statistical laws, but to refer the statistical nature of the evidence to such concepts as: error, the confounding of other intruding influences, lack of control, etc., then to deal statistically with the problems created by such concepts. The law is left virginally invariant.

Some of the problems involved in statistical relations are explored in the section so titled.

THEORY

A diversity of meanings, within and without the fields of science, has been attached to the word "theory". Let us attempt to bypass these and talk of just one general meaning. Then we can reluctantly back into the diversity by describing dimensions along which theories vary.

A theory can be considered as a system of laws.The marks of the system are an organization and generality beyond individual laws. The theory tends to be abstract and to display symbolic construction.The terms and relations expressed by the theory tend to be removed from specific, observable events, and require some transformation process to be related to direct observation of a concrete instance.

Types of Theories

Much of the controversy within the behavioral sciences has arisen from attempts to prescribe either the emphasis that should be placed on theory or the most productive type of theory, forsaking all others. The following brief, prosaic presentation gives a descriptive basis for the conflicts. Two orientations to controversies about theoretical or methodological approaches should be distinguished: 1) attempts to demonstrate the accomplishments and future potential of an approach, 2) attempts to legislate other approaches into retirement or confinement in a home for the infirm.

One basis for distinguishing theories identifies three major types: 1) Deductive Theory, 2) Inductive Theory, and 3) Functional theory. (Marx, 1963)

Deductive Theory. An extreme version suggests the formal postulate style of a mathematical system. The laws of the theory are presented as deductions from a small set of principles. Systematic organization and logical elegance are hallmarks.

Inductive Theory. In idealized form, an inductive theory is composed of abstract, general summary statements about observations. The principles are shorthand expressions of observed regularities. An induction theory does not feature intricate logical relations amongs its component principles. The laws are presented as a more or less loosely connected set, induced from the observed data.

Functional Theory. An eclectic, trial and error approach explicitly combining both deductive and inductive emphases marks those theories called functional. Such theories tend to be restricted in both scope of application and conceptual leaps beyond observed data.

Macro and Micro Theories. Another distinction between theories is based upon the size of the major conceptual units. Macro, or molar, theories are contrasted with micro, or molecular, theories. A molar theory of learning may deal with the goals and frames of reference of the learner, while a molecular theory could focus upon the changes in patterns of neural firing in the central nervous system. A macro sociological theory may deal with institutions and their relationships; a micro theory with the individuals within institutions.

Field and Monad Theories. A theory concentrating on relations among elements, rather than the elements or attributes of them, is a field theory. A monad theory attributes the essential properties to the elements - the crucial laws are *within*.

Functions of Theories

1. One set of useful functions is based on the systemic organization featured by the theory. Because the theory places knowledge into a framework, the theory serves to:

a. Store and retrieve information in an economical fashion.

b. Provide meaning to otherwise isolated bits of knowledge.

c. Confirm hypotheses or laws both by giving them the rational support from relations to other laws in the theory, and by pledging the evidence supporting other aspects of the theory.

2. Other functions are based on the power of a theory as a tool in the process of inquiry. Theories suggest lines of investigation. They offer possibilities for observational data and for laws. Theories frequently suggest relations that were previously unknown and unobserved. Guidance for forming hypotheses, arranging the design of experiments, deciding what to measure, and explaining the results of investigations are functions of theories in action.

The above paragraph begins to resemble a paid testimonial. As counterbalance, it should be noted that the impetus and direction the theory gives may be wrong. The theory may suggest new relations that don't hold and concepts that have only trivial influence. It may, by focusing inquiry, blind the investigator to possibilities outside its scope. Our tools, especially good tools, can trap us.

The Validation of Theories

Three kinds of validation may be adduced to support or infirm a theory.

1. *observable evidence.* Does the theory fit the facts? This kind of validation is the basic test of any scientific construction. With a moderately simple law of restricted range, the problem of just what confirms and what fails to confirm the law is at least relatively straightforward. However, in the case of a broad and complex theory, the degree of fit with observations may be difficult to judge.

a. More than one set of observations will be relevant. The theory may fit some sets well but not others. Theories are not usually built with easy access to components for removal and or substitution.
b. The measured correspondence with observations may not give a true or false answer but a degree of imprecision. How precisely must the theory predict or fit?
c. The correspondence with observations must be weighed against other standards. The *variety* of functions of a theory mentioned above must be given some weight.
d. The degree of testability by observation complicates the validation. Theories which lend themselves to rigorous and precise translations into observations usually receive rough treatment. Theories not so easily testable or precise have a thicker skin. The behavioral sciences' theoretical slaughter houses have developed. The buyers clamor for sharply testable theories. Once these are obtained, the skinners and butchers dissect the carcass.
e. As in the case of other validating criteria theories are compared with alternatives. The evidence usually differs in both range and kind when two or more theories are compared.
f. The observed measures by which the theory is validated will often represent a complex chain of inferences from other theories. Just what is really being tested?

2. *Syntactic Integration.* The theory has to adjust to the "in group" of knowledge. The established laws and theories, not only in the particular science, but across sciences, must not discriminate too strongly against the candidate. Some of the work done in telepathy exemplifies this criterion. While the earlier reports revealed such sloppy observation techniques as to be unacceptable, some later studies met standards of procedure. But the alleged relationships are discrepant with accepted principles across behavioral and physical sciences

This tends to be a conservative force. Discrepant theories have to stake small claims and establish a preponderance of evidence to counteract the weight of established knowledge.

Internally, two standards are applied: logical consistency and simplicity. Clear statements of terms, relations between terms, operations which relate propositions of the theory to one another, the translation procedures to arrive at observables, etc., are required for the logic criterion. The ideal, visualized in a formal deductive system, remains pragmatic only in the behavioral sciences. However, miniature systems of highly restricted applicability have been constructed for learning relatively simple material and for playing certain games. Nestle (1961), Luce and Raifla (1957)

Simplicity refers to the number of assumptions and elements the theory requires. The standard suggests keeping the baggage down to necessary items. However, simplicity can be achieved by dumping the complexities just outside the theory in the form of presuppositions, parameters for application of the theory, etc.

The standard does not suggest any notion that "nature prefers simplicity," but that some burden of justification be placed on complexity.

3. *Pragmatic justification*. The stimulation and guidance of inquiry are the bases for pragmatic validation. The points enumerated under Functions of Theories represent pragmatic considerations. A theory shaky in logic and evidence may motivate the process of inquiry. The work stemming from Freud and that from Piaget are prime examples. Such theories are useful for the questions they unearth rather than those they answer.

MODELS

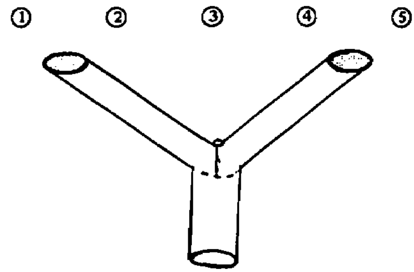
An emphasis upon models in the behavioral sciences is a relatively recent fashion but a growing one. In this section we will attempt some varieties of models, and some uses and problems they create.

The word "model" has been "in" for several years and all sorts of shopworn items are now called models. Often the term is used to designate *any* theory that has the least slant toward a logical or quantitative approach. Probably, one of Gordon Allport's literate essays on personality would not qualify, but almost any other constructions would rate this sense of the term. And, so used, the term has little justification.

A more restricted and useful view of models limits them to the structural pattern of a theory. The theory, which may contain more than the elements and relations patterned, has its abstracted pattern interpreted in the model. Within this frame of reference two kinds of models may be identified.

1. *Semantic* models presenting a set of symbols which are an analogue of the theory in terms of a set of symbols. An example is the concept of an urn filled with black and white balls. Draws from the urn proceed to reveal the operation of a theory of probability. No actual urn is involved.
2. *Physical* models are physical embodiments of the pattern which performs as the structure of the theory indicates. The planetarium and computer simulations of mental processes are examples.

An ingenious physical model for human attention is that of Broadbent (1957). The model consists of a Y shaped tube, a flap hinge at the intersection, and a set of identifiable balls.



The balls represent information; the open arms different sensory channels (the eye and ear, for example). The stem of the Y represents delivery of the sensory information. If two balls are dropped in sequence, one into each arm, the first will push the flap aside and emerge successfully. If two balls enter the pipes simultaneously, they will block each other. No message gets through.

The model makes it easier to understand Broadbent's theory with respect to the limited perceptual capacity of man and the need for selective input.

Models help much in the way that theories help inquiry. And models are often delightful, in the manner of toys. Furthermore, models have been of enormous use in the history of the physical sciences. Their fruitfulness in the behavioral sciences remains open. In view of the profusion of model building, and the greater profusion of talk about models and model building that is encountered, some cautions appear appropriate.

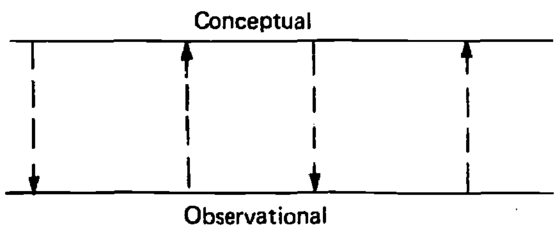
1. Elaborate arrays of symbols can be framed to codify the obvious. There is an emphasis on style rather than content.
2. The models often have such neat, tight structure that unexplored possibilities are shut off. The loose, conflictory state of knowledge is not mirrored in the model.
3. Neat construction, both symbolic and physical, usually tends

to oversimplification. All abstractions are simplifications and are useful. Models, like marriages, simply present both maximum temptation and opportunity.
4. The British Empire is pink, because maps have always colored it pink. The danger in models is that not all features correspond to the subject. The model has some of its own.
5. The models often have little empirical support and tend to direct energy from the pursuit of other evidence. Economic models of choric behavior tend to be top heavy with mathematical elegance but lacking any basic controlled observations on human choric behavior.

Perhaps the basis for concern is not the plethora of models, but models that are so similar. Allport (1955) may be worth heeding when he suggests that "the machine model in psychology had its origin not in clinical or social experience, but rather in adulation of the technological success of the physical sciences."

OBSERVATION

What we have sketched up to this point—concepts, laws, theories, and models represent the conceptual component of scientific inquiry. The other component is observation.



The above simple model of these, representing them as parallel but interacting activities, fails to do justice to the intricate and continuous interaction required. The warp and woof of a fabric may be a better analogy.

Most of the accepted techniques of observation have either been explicitly designed for, or achieved by trial and error, a reduction in the variability of observation. Observation is a straightforward reflection of all the facts and nothing but the facts. The conceptual component somehow affects what we see.

Observation starts with a guided conceptual system. This is true of voyeurs and professional researchers. We cannot observe everything to be ... We select and structure what we see. This is not simply a matter of sensory psychology; the logic of the language in which observations must be stated is inferential, and there is no way to talk about what is sensed but not interpreted. The case notes of the history of any science can reveal numerous instances of *invisible* data that became obvious after a conceptual development; and data that was dismissed as error that became crucial in light of new theory.

Instruments are of enormous importance. The techniques and technology by which we observe open new routes and channel our observations; they eliminate errors and can introduce others because of the new set of inferences needed to interpret the output of the observation instrument.

This does not imply that "everything is all relative anyway" and "we can't really know...." We do know a great deal more than we did. This "more" is based on careful observation. And careful observation is a sophisticated business.

The crucial requirement for observation is to arrange conditions so that other observers could have made the same report; that is, in the same context, including the conceptual one. Errors in observations spring from the observer, the instruments used to measure, and from distorting effects of the procedure on the subject of observation. "Controls" are procedures used to reduce error. Several standard forms of control are enumerated by Kaplan (1964).

> Observers must be trained to observe scientifically, and the very discipline which they undergo may itself subject them to trained incapacities that will produce distortions in other contexts. The "law of the instrument" may be as much at work in the process of observation as in other phases of inquiry.
>
> The difficulties in assessing the significance of observations do not stem only from the personal, idiosyncratic failings of the observer, but may be rooted in features intrinsic to the process of observation itself. A century ago Augustus De Morgan, one of the founders of mathematical logic, and more sensitive to the problems of the empirical sciences than most of his successors today, called attention to various ways in which we may confuse properties of our observations with what we suppose we have observed. Instead of A causing B, it may be our observations on A that cause B, as it illustrated by the famous Hawthorne experiments, where changes in the productivity of workers under varying condions were at last understood to have resulted just from the fact that the workers knew they were subjects of investigation. Or, A may produce only our observation of B, which would otherwise occur without

being observed, as is illustrated in the apparent increased incidence of psychosis in modern urban life, which may be attributable only to the higher frequëncy with which it is diagnosed and reported. Or, our observation of A may cause our observation of B, as in the attempt to assess the effect of psychotherapy by using the appraisals made by the patients themselves. Or, our observation of A may be necessary to the observation of B, although in fact it is B that causes A—illustrated in the relation between the manifest and latent content of a dream from the standpoint of the dreamer. Like all skilled performances, observation is by no means as simple as it looks.

There are several general procedures by which errors of observation are taken into account. These procedures are said to constitute *controls* of the observation: they are efforts responsive to the effects of the particular context or observer, designed to minimize error in assessing the significance of what has been observed.

First, we may institute procedures to *insulate* the observation, separating it from the factors that would otherwise produce error. The training of observers and the setting up of experimental situations as contexts of the observation are largely insulating devices. Special instruments may be employed, like one-way windows, or the intent if not the fact of observation may in other ways be concealed from human subjects. Astronomical observatories are located where the air is clear, and far from city lights, perhaps even in outer space. Questionnaires are pretested to eliminate ambiguities or unintended implications; and so endlessly.

Second, we may attempt to *cancel* error where its elimination is out of the question. Observations of a child's behavior, for example, except in very special circumstances, are inevitably colored by the emotional involvements with the child of those who have the most opportunity to observe him: parents, siblings, teachers, and friends. But the very multiplicity of observers may to some extent cancel out the effect of particular relationships. In general, statistical devices may be employed where there is reason to expect a great number of errors more or less independent of one another, for in that case errors in opposite directions are likely to compensate for each other. An interesting compensatory device for the human

> factor is reported by Darwin, who tells us that he kept a separate notebook to record observations counter to his theory, lest he overlook or underestimate them.
>
> In most cases, however, errors of observation can neither be prevented nor cancelled out. What is still possible is to *discount* the error, make ourselves aware of its direction, and perhaps even of its extent, and take it into account in our treatment of the observational data. In observing the shape of an object we might try to insulate against errors of perspective by viewing it from a point directly above its center; in fact we learn early to make use of the laws of perspective in interpreting what we see from any angle: coins look round as we discount the elliptical shapes they usually in fact present. Reaction times of observers can be measured and corrected for, just as astronomers correct the observed time of, say, eclipses by taking into account the time it takes for light from the event to reach us (this kind of correction was in fact the basis of the first determination of the velocity of light). In general, we *standardize* instruments and contexts of observation, not in order to eliminate an error but rather to give it a fixed and known value, on the basis of which we can shift at will what we choose to call the "zero point."

To achieve controlled observation of the "event A" that we wish to observe usually means that an experiment must be arranged. An experiment is an observation carefully planned in advance. To arrange the observation, some manipulation is usually required both for control in the above sense and so that the events (as we explore a subject our conceptual inquiry usually requests that we observe more than one event) occur. The occurrence of the required events demands a further set of controls. It is often difficult to get event "A" to occur. Observations of event "A+1" are not quite what is required. And "A" usually has some unwanted surplus. If it can't be removed or shut out we may have to control for it in other ways. This becomes more of a problem if we are concerned about events over time rather than instantaneous events. And, in the behavioral sciences the temporal notions are of great importance. What did they learn from the message? Has their attitude toward media changed? As the events of concern stretch out in time the problem of observing them as planned, and not observing unintentionally a new combination of events becomes more difficult.

Another kind of problem may block the straightforward observation of the event of interest. The *question* asked, or the tentative generalization at the forces of the inquiry, may require observation of more than one event. Perhaps a functional law which concerns the relationships between two or more processes. As an example "Sexual deprivation is positively and linearly related to verbal fluency." The required event must encompass some observable manifestation of sexual deprivation and of verbal fluency. But *in addition* to observe some indication of the relation, at least one of the two processes have to be observed in a different state. For example, either the event will be prolonged so that repeated observations of differing deprivation levels (as measured by time, although this may be a crucial decision) can be made. Or else two separate events differing in deprivation must be observed. Questions about causal, statistical, and functional relation laws usually require a series of observations.

To find a series of such required events demands an arduous search. As questions require more and more precise sets of events, the costs of finding them mounts. It has seemed more feasible to establish *control* over the occurrence of the events so that they can be produced when needed. Such controlled production of events, so that they may be observed, in an experiment. And because of most questions it appears the only means of producing the specific event needed, experiments are highly prized as sources of observation.

The requirements to observe increasing sets of different events multiply as the conceptual component of inquiry develops and as the difficulty of outright elimination of extraneous conditions increases. As the requirements increase so does the demand for control. The design of controlled observations is one of the more sophisticated topics in science. And, this seems to be one area where some of the behavioral sciences have achieved as high a level of sophistication as the natural sciences—out of necessity. They have more problems.

Other advantages of experiments are typically cited. However, I think they are consequents of event control. From this point of view much of the abrupt distinction between laboratory experiments, field experiments, and field studies is smoothed. The manipulative control is needed to arrange the event. Observation remains a similar process throughout the range from field study of a school district to simple neurone firings.

STATISTICS

The use, or even mention of statistics in the process of inquiry marks the point of immediate departure for most spectators. Even those who have been friends and lovers of behavioral science find this part of the game a source of confusion because of the mathematical manipulations; and they are mistrustful about the use of statistics. The purpose of this *brief* and *non-mathematical* discussion is to show some ways of placing the confusion and mistrust in a manageable perspective, perhaps even to reduce it, and, possibly to provide a few props so a friendly non-statistician and non-scientist can carry on short, productive, and amusing conversations on statistical aspects of inquiry with scientists.

The concern about the mathematics involved has a sound basis. The mathematics can become involved, and are sometimes way over the head of the practitioner who uses them in a rote fashion. But for most inquiries the mathematics are a tool. They are a *tool* in trying to relate observations to the generalization or hypothetical generalization that has been conceptualized. We can't use the tool skillfully without some immersion in mathematics, but we can talk about the role of the tool.

The mistrust also may have some grounds. "You can do anything with statistics," "Figgers don't lie but liars figger," "There are always some other statistics that contradict those" suggest typical feelings of doubt. A clever presentation of these possibilities is *How to Lie with Statistics* by Huff (1954). The title is correct, you can lie with statistics. However, the real master liars I have met always used words. They could lie rings around any statistician. Their behavior gave grounds for mistrust of words. But we will continue to use words, carefully when necessary, because they are productive tools.

The two major reasons for the use of statistics are:

1. The variability we discover in all aspects of the observation process.
2. The problems of inductive reasoning confronting us in making inferences about populations from samples, generalities from specifics, universals from singulars, etc.

The variability appears to be inescapable. Parts of it due to observer variations and instrument variations can be reduced. But, as we develop more refined techniques to observe and observe on a finer-grained basis, variability keeps appearing. If you measure the height of all men with a rubber yardstick marked only in 1/2 mile intervals, not much variability will be shown. If the yardstick is based on micromillimeters, considerable variability (variance) appears.

Variance occurs not only between individuals, but between groups of individuals, and between successive observations of the same event. "You never step into the same river twice," nor do you talk to the same group of people. If we were content to drop further inquiry, whenever a generalization appeared confirmed, more of the nagging variance could be ignored. After all, the whole process of conceptualization involves ignoring differences as we abstract and create categories. But inquiry is a restless process, as older generalizations are discarded or nailed down, more advanced notions pick up new variance. In fact, a large share of progress in science consists of seeking out variance and exploring it.

The major strategies in handling variance are to either use generalizations which assert invariance and then add an elaborate theory of error to handle the variance observed; to incorporate variance in the generalization. The former strategy is typical despite rumblings from some fields of physics which suggest that in *their present stage of work* indeterminance in the generalizations is a productive conceptual strategy.

Putting laws into a statistical form, to provide for variance, is useful if it does the job. Such laws typically assert a form of the patterning of a group of events and then provide a basis for the likelihood of an instance being in any part of the pattern. They are no longer considered a sorry substitute, conceptually inferior to laws asserting certainty. In fact, the laws asserting a certainty relationship are under fire from two sources:

a) whether they are as usefully related to observations as statistical laws.
b) whether in conception they are special cases of a general class of probability generalizations, cases in which it is maximal.

Whatever the observations, in any of the behavioral sciences, variance is most probable. The variance must be described before it can be accounted for by a theory of error. The descriptive use of statistics enables the investigator to describe this spread of his recorded observations in two fundamental ways:

1. The degree of dispersion or how much do the observations vary?
2. An indication of the center or central tendency of the spread.

These are the accepted minimums in any description of what was observed. If the investigator has been measuring two classes of events and is searching for possible relationships between them, e.g., is sexual adequacy related to bald-headedness in the mature male?, he will use statistical descriptors which estimate the central direction of the relationship and the spread about that estimate. A number of specific statistical tools are used to describe each aspect. Other aspects of the patterning of the variations of recorded observations can be described.

The use of statistics in assisting inductive inferences is usually termed inferential statistics, to distinguish this from the descriptive use. Often the same actual measure carries the ball for both tasks.

A perplexing aspect of science is that the reasoning from observation to ...ral statement is illogical according to our usual standards of deduction. We take the evidence from a few cases as our support for a law about all possible cases of this sort.

The problem can't be skirted by measuring every event from which generalizations are supposed to hold. There is not much interest in generalization limited *only* to a group of people at X time under Y conditions. The interest lies in a generalization that holds about other groups, or even this group at a later time.

To date, the most satisfactory approach to the inductive riddle has been a combination of probability theory and statistics. Using probability theory and constructing our hypotheses accordingly, we can make judgments about how probable a given observation is, *if* a given hypothesis were true. Furthermore, several alternative and competing hypotheses can be constructed so that results may contradict one or more, leaving the survivor(s) as the only tenable conclusion of that set. If our set of alternative hypotheses exhausts all conceivable outcomes and the observed results contradict all but one, a warm feeling of confidence attaches to the survivor.

You may hear investigators referring to probability levels or levels of significance. The chances are they are talking about the level of odds set for contradicting an undesired alternative hypothesis. Usually, only two hypotheses are conceived—the one of real interest and a dummy, which together exhaust the possibilities. The procedure is to first examine the probability of the outcome under the dummy hypothesis to see if it is low. If low enough, the dummy (often called the null or alternative) is rejected as improbable. Having covered all bets, the hypothesis of interest remains the only contender. If the dummy can't be rejected out of hand, the inquiry usually starts all over in another form. There are other strategies depending on the kind of generalization examined and the questions of interest about it. But logic is fairly similar.

Of the many possible flaws in the strategy, one should be noted. Nothing in the strategy as outlined suggests *what* hypothesis shall be conceived. The knowledge and ingenuity of the investigator are brought to its creation. Probably an infinite number of other generalizations could be subjected to the same strategy. How many are largely determined by past observation and current theoretical developments.

If this begins to appear queasy basis for establishing a science, I can only respond, "You should have seen things before." What does this add up to for the instructional technologist?

1. When he needs to describe his efforts in any precise way, for example the effect of his instructional message on the behavior of some audience, he must be braced to have some statistical measures used. Inferences about what effect occurred may require more measures.

2. Scientists are often highly involved in the statistical treatment of their labors and this involvement colors their discussion. And to most working investigators, phrases expressing the probability of obtaining the actual results (under certain assumptions) are of key concern. Adjust your listening receptors accordingly.
3. The statistics are useful tools. Their implication can be translated into the natural language, with conscious effort. By keeping his course on the logic and the purpose of the statistics, the technologist player can facilitate the translation.

And they are *but tools*, not the master. If they get out of hand, treat them by the Humpty Dumpty method. This technique is discussed in Carroll (1865).

EXPLANATION

For most scientists the purpose of their whole enterprise is to increase explanatory power. Their conceptual and observational efforts, supported by sophisticated tools, are aimed toward explanation. But, explanation in a scientific sense differs from some of the meanings used for the term. It is *not*:

1. An answer to the ultimate "why"?
2. Based on teleological or purposive notions (unless these *happen* to be the accepted laws in a particular area).

A higher order description aptly describes what is meant. Some descriptions may explain. They may describe the prior events and thus give a causal explanation. They may describe the related events and give a functional explanation. The explanation tells more than a description of just the event itself—something of the context of the event. The single event is explained when it is cast as an instance of a general law.

A law is explained by describing how it fits into a higher order (more general) law or how it belongs within a theoretical framework. The answers from a science as to "why?" can only be given in terms of *how*. The kind of "how" used to explain varies according to the variety of laws and theories accepted in the area.

Two general kinds of explanations can be identified:

1. A pattern explanation
2. A deductive explanation.

The pattern kind of explanation is logically weaker than the deductive, but important, particularly where knowledge itself is weak. In the pattern explanation, an event is explained when it is related to others so that together they make up a pattern or organized system. The event is understood by placing iinnan organized framework. Relations within the pattern fit the event to other events and/or to laws and theories—but in a post hoc manner. *After* the event we place it in a frame.

New knowledge fills in the pattern which can be extended and filled in indefinitely. This is not a deductive process. Scriven (1962) describes the patterning: "Understanding is roughly the perception of relationships and hence may be conveyed by any process which locates the puzzling phenomenon in a system of relations...A description may enable us to supply a whole framework which we already understand, but of whose relevance we have been unaware.We deduce nothing; our understanding comes because we see the phenomenon for what it is, and are in a position to make other inferences from this realization." For example, many explanations of personality development are of the pattern order. And accordingly, pretty weak explanations.

However, if *patterns become explicit* and the *relational network interlocks*, not all outcomes will fit. The pattern may accrue deductive power.

Deductive explanations are based on a *stronger set of laws and theories*. The laws close off more alternatives. What is to be explained *follows* from the general statements which function as premises. This holds irrespective of the form of the general statements which may be causal, functional, statistical, or any other sort that operate as laws.

Explanations are not final. Every explanation is in turn open to further explanation. No explanation is beyond question. This is not a vicious circle but a reflection of incomplete inquiry. One law is explained by invoking a more general one. Finality is not a characteristic of any science. The road is open. It is an open freeway in the behavioral sciences. A simple, informal test of openness in any area is to *keep asking for an explanation of the explanation given*. One round will usually find the ceiling.

Prediction flows directly from a deductive explanation. In a deductive scheme, prediction is a consequence of explanation. If conditions meet the premises of a theory or law the consequences of the deduction is the prediction.

One difficulty in the behavioral sciences is that predictions are often made when no real explanations are available. We may have accumulated a great number of observations and have an empirically based summary of them. For example, "All patients in Monmouth Mental Hospital who have been diagnosed paranoid under X conditions develop catatonic postures in Y time." We can't explain it, but the prediction appears firmly based on carefully observed instances of the same class of events. Elections can be predicted with accuracy, but explanations of them are not nearly as well grounded. we can predict without understanding. This implies that in clinical, political, and broad cultural areas where explanations in the solid deductive sense are slow in coming, we may devote some worthwhile effort to examining and improving prediction. Pattern explanation being a sort of post hoc fit offers no prediction power. Only as the pattern tightens into a deductive system does prediction become possible.

If prediction is afforded by a scientific explanation then the possibility of control of the event appears. The weaker sense of explanation in terms of the pattern model offers little hope of control. Furthermore, control in any case may remain only a possibility if we are technologically able to do little about it. Thus, we may be able to explain the large scale social movements but do not have the means or concentration of power to manipulate them.

However, prediction does imply control in another sense. If we predict, for example the city riot, we may not be able to prevent it but we can take appropriate action to live with it or despise it.

The precise control demanded by a comprehensive deductive system which yields specified predictions may be a long time coming. But an engineering compromise is possible. I refer to the development of empirical generalizations based on pilot attempts at control. The pilot attempts are themselves based on the available knowledge. The empirical generalizations may contribute little in the way of higher level generalizations. The emphasis of these engineering studies is to use available basic knowledge in an on-the-spot inquiry in order to establish *sufficient* conditions for control. The conditions may be overloaded with strength to achieve the outcome. But the aim of the inquiry is to discover a feasible route to the desired terminal. Several of the preceding papers are based on such an engineering approach. Satisfyingly, I find that all the processes and problems of forming and using concepts, laws, and theories; of grappling with observation, statistical and inductive inferences, seem to be as central to these practical approaches as to any of the more austere behavioral sciences who are suspected of paternity.

FISSIONS WITHIN THE BEHAVIORAL SCIENCES

Within the behavioral sciences, particularly within any one of the disciplines, pronounced differences of orientation exist. Several of these differences have led to hostile outbreaks by verbally armed groups, and even to secession from professional associations. The prudent technologist will keep an open eye for signs of such partisan activity. The following list of such issues is presented without modifying or adjudicating remarks *except* for one editorial note: Fiats to dampen any one of these divergent approaches on the grounds of small expected yield are not well taken. Available knowledge gives no preponderance of evidence for or against any one of the confounding protagonists.

Issue 1

The appropriate level of analysis.

Concepts and laws differ in the size of units upon which they focus, varying from enzymes at a neurone juncture to interactions between organized groups of people. At which level should effort be concentrated? The micro proponents cite progress in the natural sciences, particularly physics. The macro forces counter that we cannot blindly borrow from others; we must use what is appropriate to the area of concern. Furthermore, many laws of physics are based on field and statistical notions where mass behavior can be explained but not that of individual elements. The micro group responds that all explanation will eventually be reducible to theories about fine-grained particles and movements.

Eons ago, several of my fellow graduate students departed from personality research to animal learning in order to get closer to the fundamental unit level of analysis. They later left learning to migrate to physiological work for the same reason. I understand they then considered leaving physiology for biophysics....I must look for them someday.

Issue 2

Theoretical vs. empirical

The appropriate position of theory is not agreed upon. The empirical group feel that there are *no* useful theories at present, merely some lower order generalizations. And, effort should be made at inducing more generalizations from observation. Theoretical camps maintain we need more powerful theories and *only with these as tools* will our observations yield anything approaching maximal production.

A closely related issue is the degree of emphasis upon concepts and principles that are not directly observable. The atheoretical group stays close to the overtly observable. Their opponents feel free to posit a welter of variables and constructs that can only be observed through a chain of consequences.

Issue 3

Control vs. expansion

The control faction maintains the need for fuller understanding of *restricted* problems. Their emphasis is upon carefully controlled observations and thorough analysis. As their opponents describe them, "They don't get anywhere but they *are solid.*" The expansionists sometimes diverge into two movements: One emphasizes the construction of new generalizations, concepts, etc.—often with but a passing gesture toward the tedious and pedestrian activities of confirmation. The other seeks to expand directly into areas of social concern, the issues and problems of the times.

Issue 4

Laboratory vs. field

This is related to issue three but cuts across other divisions. The lab camp emphasizes the need for precise observations. Usually these can only be made under experimental treatments within the manipulable setting a laboratory offers. The field camp maintains either that this is so artificial that the phenomena are changed, or that the real behavior of interest can't be so studied, or the city. Each feels that the other's data is worthless.

Issue 5

Idiographic vs. nomothetic

This fissure is between emphasis on studies of the individual uniqueness of a single case vs. emphasis upon abstracted and general laws covering sets of similar cases. The terms are borrowed from Windelband, a disciple of Kent, who asserted a distinction between sciences seeking laws–*nomothetic* sciences, and sciences studying individual and unrepeatable phenomena—*idiographic*. The term *verstehen*, understanding, is used to characterize idiographic knowledge.

The weight of published opinion, including individual difference studies, runs toward a nomothetic approach. The nomothetic proponents maintain the only scientific way to understand an individual is to place him along and within some general concepts and principles. The idiographs retort that this is only a minor first step toward understanding. There is a lot more to an individual than the general laws can reveal, and that this "more" can be approached by special methods of investigation.

THE B.I.B.S. GAME

Basic Interaction with the Behavioral Scientist: Plays and Countermoves

In this introductory game the overall objectives of the technologist player are;

1. To discover the relevant information the behavioral scientist has to offer.
2. To grasp its meaning clearly and fully so that sound decisions can be made regarding
a. whether it is useful to the technologist's present purposes
b. if so, where and how it fits.

Such objectives appear sufficiently malleable to embrace the three interactions identified in the beginning of the chapter. The moves suggested below constitute a crude operational specification of their meaning. The moves will be listed as if the interaction involved a live behavioral scientist (labeled hence as B.S.). Other interactions may be viewed as a proper subset of these.

Openers

Encourage an expression of the B.S. player's current scientific interests, whether or not these seem at first to be applicable. This sets a favorable climate and the odds are that he views all other problems as peripheral spin-offs. Use this to determine if the B.S. has a noticeable position relative to the fissionable issues mentioned.

Present your purposes in the interaction but don't close off the set. He may amplify, clarify, etc. if allowed.

Initial Thrust

Scan the input for fit from your perspective out of the components that he stresses. Probably a *law* or hypothesis is the appropriate target here rather than a concept or theory.

Ask B.S. to restate the generalization.

Moving In

Get clarification on the relationship
a Causal, functional, or something else?
b. How precisely is it posited, e.g., just larger than, or tend to decrease, etc., or is a more exact degree specified?
c. What are the limits? What would *not* be the relationship?

Examine the Concepts

a. Ask for some examples. Press gently toward operational definitions.
b. Search for the fuzzy borders—examples that are not quite the concept.
c. Find the kinship of the concept. What ideas are close to it but specifiably different?

Recreate

Put the law back to B.S. using your own examples. Smile firmly as B.S. points out your errors.

Down the Ladder to Observation

a. Ask pointedly about the evidence supporting the law. What were the samples, just how observed?
b. Naively inquire if there has been any contradictory or doubtful evidence.
c. Suggest that B.S. point out where the evidence could use some shoring up.
d. If b. and c. yield little, ask in a quiet, musing way what could possibly contradict the law. Gently but firmly press for specific examples.

Up the Ladder to Theory

a. Within what systemic position does the generalization belong?
b. What general concepts or principles hold this law in position within the theory?

NOTE: Here you have a clear choice to recycle through each related law, or opt out with an affirmative nod.

c. Are there any other systems or approaches that would find this notion discordant? How so?
d. Now ask why or how the relationship of interest works. Push till the B.S. yields to an admission of ignorance. If you obtain an explanation, ask what brings it about, how the explanation works, what causes *it*, etc.

NOTE: Cease concern that B.S. will be bored or upset by the interrogation. This is probably his favorite topic and no one has ever taken time to really listen actively.

Castle and Lead to the Application

a. Maintain the participation of the B.S. by applying some mild social reinforcer, e.g., smile, murmur of approval, nod, etc.
b. Now restate your problem and ask for suggestions from the B.S.
c. Reinforce each suggestion, but point out more detailed sub-problems.

d. After each suggested application is clarified, invite an alternative.
e. Summarize the plausible suggestions. Accept corrections.
f. Ask the B.S. to go through an imaginary trouble-shooting sequence with you, e.g., the suggestions have been incorporated but the production is a flop.

Where would he search?
What criteria for change?
How go about correcting?

g. Explore extensions and implications. Assume the production was passable. Stimulate the B.S. to suggest next steps; how could this be used as a springboard?

Reinforce Again, and Exit

Note: Special purpose games are available for the more advanced player. Also self scoring manuals.

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CONTRIBUTIONS OF BEHAVIORAL SCIENCE TO INSTRUCTIONAL TECHNOLOGY 1

The Affective Domain

The seven chapters of this volume present at least seven diverse viewpoints written by seven different sets of authors. Both the chapters and authors possess one common attribute: A concern with developing instruction which interests, involves and motivates learners. Seven facets of human feeling, or *affect,* are presented by authors who have been engaged in the basic research and instructional applications of that particular approach. The book is intended primarily for the instructional technologist who is involved in designing, developing or revising instructional systems. However, the volume is useful to anyone concerned with the improvement of instruction.

CONTRIBUTIONS OF BEHAVIORAL SCIENCE TO INSTRUCTIONAL TECHNOLOGY 3

The Psychomotor Domain

The Psychomotor Domain is concerned with more than human development. It is more than children playing with blocks or learning to play the piano. Each of the authors in this volume addresses himself to defining parameters or establishing ways of working with variables o the domain. The net result is not a neat conceptual package but a vortex of ideas which reflects the present state of thought, research and experience in the psychomotor domain.

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