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An Information-System Approach to Theory
of Instruction with Special Reference to the Teacher

by R. M. M. R. M.

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An Information-System Approach to Theory
of Instruction with Special Reference to the Teacher

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AN INFORMATION-SYSTEM APPROACH TO THEORY
OF INSTRUCTION WITH SPECIAL REFERENCE TO THE TEACHER

INTRODUCTION

This is a rough-cast attempt at conceptualization or theory building with respect to the instructional process. The purpose is to block out some of the conditions and behavioral constructs which may be hypothesized to contribute to teacher behavior and the instructional process.

The beginnings of the writer's thinking in this area date to the late 1930's when his primary interest was in the unique role of "learning" and the concomitants of adaptive change in human response, particularly the psychological constructs implied by the terms "motivation" and "persistence," in the description of individual behavior (33, 34, 35). Concern about the teacher as a guide and organizer of formal learning--and with the abilities-knowledge of teachers, as those variables contribute to teacher behavior--developed through the writer's association with the American Council on Education's early programs of National Teacher Examinations (30, 32). Conduct of the Teacher Characteristics Study for the American Council on Education and The Grant Foundation, beginning in 1948, focused attention upon a number of variables such as "behaving styles," "affective sets," and other personal-social characteristics of teachers (31).

At the Annual Meeting of the American Educational Research Association in 1955, a first approximation of a theory of teacher behavior was attempted. Part of the paper presented at that AERA meeting, and later published as a journal article (36), was devoted to making a case for attention to theory in studying teacher behavior and to reviewing some of the characteristics of theories and the advantages theoretical models offer the researcher. But the focus of that statement was on (1) a definition of teacher behavior, (2) the setting forth of several postulates that seemed basic to the conceptualizing of teacher behavior, and finally, (3) the presentation of some general equations and a diagram which were intended to make explicit: (a) that teacher behavior consists of instrumental responses and usually is a function of the interaction of characteristics of the pupil and operating conditions or characteristics of the teaching situation; (b) that teacher behavior may be conveniently described in terms of the concepts of "general systems theory"; and (c) that an adaptation of Sears' "dyadic sequence" paradigm provides one useful way of analyzing the systemic interactions of pupil and teacher. The paper concluded with the opinion that research on teacher behavior was reaching a point where the first steps toward the organization of evidence into a theory of teacher behavior was possible and that such study and systemization (theory development), in combination with proper attention to specification of problems and careful design, could reasonably be expected to shed increasing light upon our understanding, first, of teacher behavior, and, second, of how teacher behavior influences pupil behavior and how certain kinds of teacher-pupil relationships may be identified, predicted, and cultivated (36).

Later, after several iterations and some revision of the postulates and assumptions, essentially the same basic concepts were summarized and paradigms illustrating the integration of teacher behavior and the interaction of teacher and pupil were presented in an early chapter of the publication, Characteristics of Teachers, a report of the research conducted by the Teacher Characteristics Study (31, p. 15-25).

The conceptual framework to be described at this time represents a further elaboration of the earlier-stated viewpoints, although the theoretical model still is gross and general. In this paper, the writer's position is presented in greater detail, additional constructs are introduced and emphasized, and an effort is made to look further into some of the implications. The teacher system and the pupil system are described in terms of the essential characteristics of all systems--information flow or information processing.

The influencing conditions that have led to this "information system theory of instruction" are four: (1) the thinking and the research growing out of the Teacher Characteristics Study (31), relevant teacher behavior research reported by other investigations, and experience with the data accumulated in connection with the National Teacher Examinations; (2) the introduction of the concepts of "general system theory" (4, 5, 6, 9, 16, 24, 43); (3) Sears' direction of attention to the "dyadic sequence" as an explanation of social behavior (37); and (4) the growing interest in concepts associated with information theory and communication theory (10, 11, 17, 19, 20, 21, 22, 23, 38, 39, 42).

To provide background each of these influences will be briefly reviewed at this point; some of them will be discussed in greater detail later in the paper.

The Teacher Characteristics Study

The Teacher Characteristics Study was an eight-year research effort, consisting of over one-hundred subinvestigations, which was directed at (a) the determination of major teacher behavior patterns observable in the classroom, (b) the development of inventory estimates of certain teacher characteristics, (c) study of background and environmental variables related to teacher behavior, and (d) study of relationships between teacher characteristics and observed pupil behaviors. The Study started essentially from scratch, with relatively few assumptions made about the roles of teachers. Instead, the design dictated "going into the classroom" and employing trained observers to systematically observe and record what transpired when teachers and pupils reacted and interacted in the learning environment. Following phases of the Study attempted systemization of the direct-observation data thus collected, determination of relationships between such data and other information about teacher behavior, discovery of typical patterns of teacher characteristics and their relations to various conditions of teacher status, identification of information that appeared to offer clues for distinguishing "highly assessed" from "lowly assessed" teachers, investigation of the interactions and interrelationships among pupil

behaviors and teacher behaviors, and the classification and mapping of pertinent information which might provide a basis for a theoretical model of teacher behavior and instruction. All of this has been described in various journal publications and in the volume, Characteristics of Teachers (31).

General System Theory

"General system theory" is a term introduced, so far as the writer is aware, by Ludwig von Bertalanffy¹. The general system construct proved attractive to behavioral scientists, particularly a group at the University of Michigan (who had begun to explore the matter while members of a University of Chicago faculty study group), and came to the attention of psychologists and educators largely through the publication of James G. Miller's article, "Toward a General Theory for the Behavioral Sciences" (24).

"General system theory" is proposed as a super-theory or a multi-theory, i.e., a general model which may provide the framework for concept organization in a number of areas and disciplines.

Like all theory, general system theory starts with certain definitions and assumptions.

A "system" is defined as a set of elements or subsystems (each of which may possess some degree of independence but at the same time is an integral element of the larger ensemble), together with the relationships between the elements and between their properties. The elements or subsystems are centralized and organized by a communication network which permits interaction and makes for interdependence so that they function as a coordinated whole to produce some process and/or product which is unique to that particular system.

The systems with which general system theory is concerned are "open systems," i.e., systems that are characterized by mutual exchange of energy or information with other systems. Closed systems also exist, but a closed system can not communicate with its environment; there are no inputs of energy or information from other systems outside its boundaries, and there are no outputs which affect other systems. A chemical reaction brought about in a sealed container is literally self-contained. It represents a system in the sense that there is interaction among components and a product unique to the system may be produced, but the system is "closed" insofar as there is no exchange of energy with other components or systems comprising the environment of the system. The principles of thermodynamics, including the "second law" which states that

¹Bertalanffy states he developed the idea of a general system theory during the late 1930's but the material was not published until 1945 (5, p. 3)

entropy (a measure of unavailable energy, and therefore of probability, chance, disorder, or uncertainty) can never decrease but must increase to a maximum at which time equilibrium is reached, apply to closed systems. And in a closed system, the final state always is completely determined by the initial state or initial conditions.

In contrast, an open system such as a living organism or a social group (i.e., teacher and pupil) is capable of receiving information or energy and of transferring information/energy to other systems. Furthermore, it is not bound by physical principles such as those of thermodynamics, for it often avoids entropy and develops toward increased organization and therefore decreased disorder and uncertainty. And it can reach the same final state (the principle of equifinality) starting from different conditions and proceeding by different courses of action; the same end-product can be attained in different ways (e.g., the teacher may be influenced by varying inputs including feedback inputs and may employ different techniques or procedures to communicate a particular concept to different pupils, or to clarify and assure the intended behavior on the part of a single pupil).

As noted, a closed system must eventually reach a state of equilibrium characterized by maximum entropy and minimum free energy. An open system may attain a stable time-independent state, i.e., steady state, for those variables which must remain within limits for proper system functioning, this being possible as a result of the continuous exchange of energy among the components of the system and between the system and its environment. But in performing its function the system cannot be in a state of complete equilibrium; it will be continuously adapting and reacting to its environment, i.e., tending to maintain a steady state, in order to continue in operation and perform its unique function.

An open system may be defined, then, as a system that can be changed, or is adaptive, and which engages in energy and information exchange, both with its component subsystems and with other systems which comprise its environment. An open system must be capable of receiving inputs and of producing outputs. But the inputs vary from time to time; and the outputs may be altered. This property of adaptivity permits maintenance of the steady state over periods of time.

Important to the maintenance of a steady state of an open system are negative feedback processes, the source of which is the outputs of a given state of the system--these, in turn, providing additional inputs for the future functioning of the system. The feedback principle may be illustrated by various examples: action of the thermostat in opening or closing valves of a heating or cooling system to maintain room temperature within selected limits; turning the front wheel of a bicycle in the same direction a rider may begin to fall, thus maintaining balance; modifying sensor-motor responses in throwing darts at a target in response to cues provided by visual perception of the results

of previous throws; directing cognitive learning in response to knowledge of examination questions correctly and incorrectly answered.

If feedback from the output of a system is not possible, the system cannot adapt and maintain its stability, and even though it may persist for a time it will degenerate and become sterile; it will not continue to attain its objectives or produce the expected outputs.

Open systems also are characterized by progressive segregation, a system dividing into a hierarchical order of subordinate systems each of which may gain a certain amount of independence but still significantly retain the essential interdependence which characterizes the over-all system. Progressive systematization also may take place, where there may be addition or development of relations between subsystems/elements, or strengthening of pre-existing relations, or the aggregation of systems to form a supersystem.

A system in this sense, then, is an organized but modifiable set of elements forming a unit, bounded by space and time (i.e., characterized by boundary regions which distinguish it from other systems in its environment) which engages in energy exchange both (a) among its subsystems/elements and (b) with other systems with which it is coordinate, or with the supersystem of which it is a subsystem.

General system theory assumes that the universe is made up of such open systems which form a hierarchical order. A cell, an organ, an organism as a whole (such as a person), a social group, a nation, a culture, etc., all may be viewed as open systems. Thus, both aggregation of systems into supra-systems and segregation within a system into subsystems are provided for. The operating principles are assumed to be similar regardless of the size or complexity of the system.

Among the postulates of general system theory are ones which involve the ways that (1) inputs (i.e., the conditions which act on a system) affect the system's functioning and influence the outputs, and (2) the ways that outputs (i.e., observable phenomena representing the acts of a system and involving energy exchange across the system's boundary) vary with different inputs and different configurations of system elements, and also ways in which the outputs affect both the system producing the output and other systems receiving the output.

Corollaries of these postulates include the assumption of (a) "coded" inputs which may be described as inputs that are linked so that one system produces an output which, as an input to another system, conveys information, i.e., nonrandom energy that is characterized by form or meaning, and (b) "uncoded" or random inputs. Coded inputs, consisting of nonrandom signals, are the opposite of random energy or noise. Uncoded inputs, or energy changes which convey no information, constitute a major problem in system operation

in that they interfere with the orderly information flow which permits systemic functioning and distorts information exchange among systems (e.g., between teacher and pupil).

Additional principles sometimes are stated and the concepts of equifinality, adaptiveness, organization, steady state, feedback, and others may be explicated; but the foregoing skeleton discussion provides a satisfactory introduction to the system concept.

Various theorems and hypotheses of general system theory may be derived and tested. Miller (24) suggests such hypotheses, for example, as: "Coding is a linkage between subsystems whereby process A is coupled with process B so that either will elicit the other in the future, thus involving retention of a linkage over a period of time." "Uncoded inputs can result in disequilibria or strains, which serve as primary 'drives.'" "Reduction of disequilibria is drive satisfaction and goals may be interpreted as internal strains which elicit efforts to achieve inputs of energy and information that will reduce the strain toward an equilibrium point."

The implications of general system theory for many behavioral processes, including teacher behavior and pupil behavior, may readily be noted by the reader.

Sears' Dyadic Sequence

A decade ago Sears (37) suggested a reasonable expansion of the basic "monadic unit of behavior (a model of the behavior of a single isolated organism considered as though it functioned independent of other organisms, e.g., $S \rightarrow O \rightarrow R$), which various learning theories have employed, into a dyadic one which describes the combined actions and interactions of two or more individuals. The assumption that the "dyadic unit" construct is essential if relationships between people are to be taken into account certainly is of interest to the teacher-behavior theorist; the dyadic approach strikes at the heart of the teacher-pupil relationship problem. In adaptations of Sears' model, the writer (36, 31) attempted to describe teacher behavior schematically in terms of the dyadic behavior sequence. Essentially, the paradigm that was presented suggested the two-direction relationship between the teacher (Alpha) and the pupil (Beta) and indicated how the instrumental acts of both teacher and pupil interacted with one another and with the situation or environmental event which provided the setting for the behavior. Although feedback loops were not explicitly indicated in the diagram, the modified behavior of the teacher and of the pupil after a particular sequence of behavior in a specified situation provided an example of the effects of consequences of acts on future behavior.

Information Theory

From the engineering standpoint, information theory had its beginnings in papers published in 1928 by Hartley (17) and expanded by C. E. Shannon (38).

Information theory in this classical sense is highly mathematical and is concerned primarily with the amount of information that can be communicated over a system consisting of a Source-Transmitter-Channel-Receiver-Destination. Information is defined in terms of electronically generated signals and a convenient, and usable, unit for the measurement of such information is introduced.

The basic information function employed is H . H is a function of the probability of measures generated by the source $\underline{x}$. The measure of amount of information in a message, or set of signals, transmitted by a source $\underline{x}$, is derived from the reduction of possible outcomes or alternative choices resulting from selection of a particular message. Information transmission, it should be observed, is important only when there is doubt, when alternatives exist and choice, selection, or discrimination are called for. Whenever the number of alternatives is reduced by one-half, one unit or "bit" of information is gained. A source chooses a particular message out of a set of k messages it could send. When a source selects a message, it reduces k to k/x and the amount of information is $\log_2 x$ bits (i.e., the amount of information that must be transmitted to inform the destination of the message what choice was made). If a message having the probability p is selected from a set of $1/p$ alternative messages, the amount of information that must be transmitted is $\log_2 1/p$ or $-\log_2 p$.

$H(\underline{x})$ is the mean value of $-\log_2 p_i$. The equation may be written:

$$H(\underline{x}) = \sum_{i=1}^k p_i \log 1/p_i$$

or

$$H(\underline{x}) = \sum_{i=1}^k p_i (-\log_2 p_i)$$

H , thus, is a probability estimate or a measure of uncertainty and $H(\underline{x})$ is the average uncertainty per message for source $\underline{x}$. $H(\underline{x}, \underline{y})$ represents the mean uncertainty of a message transmitted by source $\underline{x}$ being received by destination $\underline{y}$.

The function T also is basic in applications of information theory, T representing a measure of relatedness or contingency. If $\underline{x}$ is taken as the source and $\underline{y}$ as the destination of a message, $T(\underline{x}, \underline{y})$ represents gain in certainty when a message has been transmitted over a channel.

$$T(\underline{x}, \underline{y}) = H(\underline{x}) + H(\underline{y}) - H(\underline{x}, \underline{y}) .$$

Classical information theory is devoted largely to the amount of information so measured that it is possible to communicate under different conditions

It should be noted that the engineer is interested in the transmission of signals in the form of physical energy (e.g., electricity, light), and not with the purpose, or with the semantic or pragmatic meaning, of messages. For the engineer, if the signal is transmitted with fidelity, the message has meaning. Classical information theory is syntactic in that it is concerned only with physical signs themselves and statistical relations between signs. However, in the usual sense in which the term is employed, information is defined in semantic and/or pragmatic terms and is considered to refer to events and objects in the everyday experience of persons. In the pragmatic sense, with which the psychologist and educator are likely to be interested, information involves the users and their responses to messages (i.e., it focuses on the meaningfulness of messages in the sense that a series of nonsense syllables differs from a meaningful sentence.

Since the days of Hartley, and later Shannon and Wiener, classical information theory has undergone extensive development. A number of ramifications and adaptations have also appeared. It has been brought to the attention of the behavioral scientist particularly by G. A. Miller and others associated with him (20, 21, 22, 23).

Whereas classical information theory concerns itself with a highly technical and mathematical definition of information, other individuals have indeed considered information in terms of the semantic and pragmatic approaches noted above (10, 11, 25, 27, and others). It is in this latter sense (i.e., from the semantic and pragmatic points of view) that "information" is used in this paper and from which the discussion which follows will take its departure.

SOME DEFINITIONS AND TERMS

It is necessary that the basic terms used in this paper be defined from the standpoint of the writer's conceptual framework. A general definition of instructor behavior will be introduced--a definition which considers the teacher as an information-processing system that functions for the purpose of aiding the student in acquiring an appropriate behavior repertoire. Next, to help to make clear the definition of teacher behavior, "system" and "information" will be interpreted in terms of the meanings they convey in this theoretical approach. A broad statement of the pupil behavior goal of education will also be presented.

Teacher Behavior

Teacher behavior here is genotypically defined in terms of a set of hypothetical constructs which are assumed to characterize the teacher-system and which are postulated to interact and mediate the observable teaching response in a particular situation. The functioning of the teacher-system is described as teacher "information processing."

The theoretical framework proposes, then, that information processing on the part of the teacher-system culminates, in a given teaching situation, in certain overt and directly observable information forwarding responses directed at the students.

The ultimate purpose of the acquisition of information by students is, of course, its subsequent retrieval and use. The information may be retrieved by the individual either in essentially the same form in which it was originally received and learned, or in some adapted form which is altered to permit the application of earlier received facts, concepts, and rules to new situations; or even to the discovery of previously unrecognized information; or, through recombination to the creation of new concepts or products.

Instructor information processing, culminating in teaching behavior, is accomplished to facilitate the students' attainment of specified behavioral goals which include the acquisition and development of skills, procedures, knowledge, understanding, sets, work habits and other behaving styles, attitudes and value judgments, and personal adaptation-adjustment patterns acceptable to the culture or community in which the teaching is accomplished. And, in addition, to promote this pupil acquisition-development "in optimum time, with optimum retention and transfer, and with no harmful personal effects."²

The observable information-providing responses of the teacher are, then, postulated to be instrumental and telestic in nature. They are directed at influencing the acquisition of specified information-behavior in the individuals who are being taught.

The theoretical position presented in this paper further assumes that teacher information-providing involves five general classes of teacher behavior: motivating-reinforcing; presenting-explaining-demonstrating; organizing-planning-managing; evaluating; and counseling-advising.

Further Comments on the Concept of the Information System

The system concept has already been introduced and the dependence of system functioning upon information/energy exchange noted. In the title of the paper and frequently in the discussion which follows the term "information system" is used. Such usage is justified to emphasize the information-exchange aspect of system interaction. Generally speaking, then, a system may be summarily described as an identifiable assemblage of complexly organized interdependent subsystems (which may be behavior variables characterizing an individual,

²B. Othanel Smith. Educational psychology and philosophy: values and science. (Unpublished paper) Presented at the 1957 meeting of the American Psychological Association.

individual persons forming an identifiable group, etc.) which are united by a common information-flow network; which are characterized by a regular (i.e., lawful, orderly) form of interaction; and which operate as an organized whole in sensing and processing certain classes of inputs to bring about the attainment of some objective, or produce some characteristic effect or output.

Because of the necessary sensing, filtering, transforming, and channeling involved in the exchange of information (a) among elements or subsystems of a system, and (b) with other systems in its environment, any system may be thought of as an information-processing system. Information energy exchanged among the elements of a system, or transmitted from one system to another (as from teacher to pupil), may be described as communication or information flow.

The sense in which "information" is employed in this theoretical framework is a much broader one than that applied in electronic information theory. Here the term relates information to meaningful facts, concepts, or rules. The information flow coordinating the teacher-system, or the pupil-system, and characterizing the interaction of a system with other systems, therefore, involves the exchange of meaningful messages in the form of facts, concepts, or rules. The point of view is a pragmatic one (15, 11).

The concept of a system as it is used in this paper assumes then: (a) that the system produces an observable end product or output; (b) that this output fulfills some defined objective; (c) that the output is associated with certain necessary conditions, or inputs; and (d) that there is some sort of mediation in the input-output flow of information within the system (i.e., orderly interaction or information flow between the system inputs, internal and external, and the elements or subsystems comprising the system under consideration--that interaction being unique to the particular system, being instrumental in the maintenance of a dynamic equilibrium of the system,³ and being controlled by identifiable, though often modifiable, combinations and sequences of operating principles). The operating rules or controlling principles are inferred from analysis of the observable inputs, outputs, concomitants, and subsystems, and from their discernible interdependence.

The Concepts: Information; Information Processing; and Information System

Information is defined for the purposes of this viewpoint as stimuli (or energy forms) that convey pragmatic (15) meaning. That is, information signifies

³Bertalanffy (5, p. 3) notes that the concept "dynamic equilibrium" was applied in describing living organisms at least as early as the mid-19th century by Johannes Muller and Dubois-Reymond; and that open systems in thermodynamics were discussed by Defray in 1929.

something that is potentially subject to common identification by the transmitter and the receiver of the information. As such, information is distinguishable from noise or uncoded stimuli which are void of intended denotative or connotative properties.

Since the term "information" is used to refer to communicable facts, concepts, and rules that possess meaning for the receiver/destination, the receiver-destination as well as the transmitter must be considered an active and integral element of the communication process.⁴ Information, as here defined, possesses meaning for the receiver/destination, in the sense that the facts or rules communicated either (a) provide a meaningful context or fit into some existing context, and (b) provide associations and cues for their selection when there is need for retrieval for application to future behavior or courses of action.

When the teacher or the pupil is described as an information-processing system, "information processing" means the selection, preparation for transmission, and forwarding or communication of some meaningful information or message in a manner which seems most likely to lead to understanding of the message by its recipient and incorporation of the information into his hierarchical association map.

One way of conceptualizing teacher information processing is to consider the teacher's activities as a five-phase sequence consisting of:

1. Sensing, identifying, and classifying of information inputs.
2. Evaluating potential courses of action in light of the pupil behavior domain involved, the content of the information to be communicated, and

⁴Information and the communication of information thus is viewed chiefly from Peirce's (15) "pragmatic" definition. (Peirce wrote of three major divisions of the theory of signs: the syntactic, which is concerned with physical signs such as electrical signals and their relationships; the semantic, which is concerned with the referents of signs--i.e., the objects, events, etc., signs stand for--and their relationships; and the pragmatic, which is concerned not only with the objects, events, and relationships signs stand for but also with the responses evoked in receivers/users of the information communicated by signs.) The pragmatic approach implies that to be communicated successfully, messages must take into account both the sender and receiver (i.e., source and destination), and their capabilities, attitudes, sets or states of mind, past experiences, and current conditions. Peirce also says that from the pragmatic standpoint a sign/information must be capable of evoking responses (on the part of the recipient) which themselves are capable of acting as signs for the same object, event, or relationships referred to when the sign was employed (11).

the information form and channel consistent with the intended pupil use of the information.

3. Decision making, involving the selecting of appropriate information content and appropriate transmission channels or media.
4. Programming or the logical-psychological ordering and arranging of the intended information output.
5. Transmission of appropriate information via appropriate channels (i.e., teacher behavior).

The teacher's communication or forwarding of information may take any one of a number of forms. It may consist of the communication of a message in the form of verbal symbols as in spoken or written language. It may consist of a set of quantitative symbols. It may be in the form of physical gestures, facial expressions, or personal-social behaving styles. It may take the form of a demonstration (either in the limited sense that a chemistry experiment is demonstrated by a teacher, or from a broader point of view that the individual teacher serves as a model whose behavior may be imitated by his pupils or students). And, of course, it may involve the use of learning aids (i.e., media) of various sorts.

Similarly, the information transmitted may be related to any of several kinds of content associated with the several so-called behavioral domains. It may have to do with cognitive-type materials (e.g., knowledge, concepts, etc.); with affective content (e.g., attitudes-values, temperamental-emotional characteristics, etc.); or with psychomotor skills.

The purposes for which information is processed and communicated also may vary in an instructional theory cast in terms of the information system. The information may serve the purpose of simply reporting, as in the case of the news that is printed in the newspaper or broadcast over radio or television. The information may perform a direction-giving, or a command-and-control function. It may be intended to describe and clarify some policy. It may be employed for the purpose of coordinating action that requires mutual exchange of information. It may be employed by the instructor simply to clarify issues or problems. Or it may be used to summarize or to classify facts, that may be recombined in different forms to promote new discoveries.

In the teaching-learning process, the immediate purpose for which information is processed is, of course, to facilitate the pupils' acquisition of knowledge, understanding, skills, procedures, attitudes, and the like. It is worth repeating, however, that simply because some particular item of information has been transmitted and is received by the pupil does not, in itself, imply acquisition of knowledge or skill. Such acquisition depends upon the active response of the learner and on the existing conditions affecting the

learner as an information-processing system when the information is received. Furthermore, the same information content, transmitted in the same way, may have different meaning for different pupils, i.e., individual differences among the receivers of information must be recognized.

A basic postulate of our earlier conceptualization of teacher behavior, and one which is well suited to the information-processing description of instruction, is that teacher behavior is social in nature. The teacher cannot be described independent of the pupil since the teacher and pupil interact, and teacher behavior (i.e., teacher information processing) is influenced both by direct transducer inputs from the pupil and also by negative feedback provided by the consequences of teacher information forwarding.

From the standpoint of this theory of teacher behavior and instruction, each teacher, each pupil, and each administrator may be thought of as an information-processing system. Each may be considered a separate system--in the true sense of the description of an open system. Or, each may be considered an element, or subsystem, forming some combination of teacher and pupils, or teachers-pupils-administrators, and in this case the designated combination may comprise the system appropriate for consideration. As an information-processing system, any individual, or combination of individuals, exists primarily to filter incoming information (including that which is retrieved from information previously learned and "stored" in the memory), make decisions regarding it, and control information that is to be transmitted, or is to be stored (i.e., the output).

The classical information theory⁵ analogy applies, at least in some part, to thinking about teaching-learning in terms of information processing. In a sense, a teacher (or a pupil) simultaneously may serve as a transmitter, a channel, and a receiver of information. Irrelevancies, distractions, inadequately

⁵It should be recalled that the telephonic analog, is concerned to a large degree with the fidelity of the system in reproducing at the destination the signals introduced by the source. It attends particularly to the entropy of the source (i.e., the information content per character), the source rate, the capacity of the transmitter, channel and receiver, and the amount of noise in the system. It is concerned with the amount of information (i.e., the amount of freedom of choice involved in the selection of a message consisting of a combination of impulses which may be represented in binary terms) that can be communicated with a relatively simple electronic system. Noise or interference of any kind which tends to destroy or block communication of the inputs comprising the message becomes an important consideration since it may disrupt the communication of information either in the transmitter, the channel, or the receiver.

organized and sequenced lessons (information), improper choice of channels, lack of provision for feedback, and other conditions disrupt communication and prevent information from serving its intended purpose. Obviously, the concept of the teacher, or the pupil, as an information-processing system dealing with the flow and control of meaningful facts, concepts, and rules cannot be wholly analogized with the Wiener-Shannon model of information theory. This theory involves a relatively simply system, fairly readily subjected to formal mathematical modeling. Teacher or pupil information processing of meaningful (i.e., semantic/pragmatic) information is infinitely more complex. Interactions, of various levels and orders, are literally impossible to enumerate. Prediction and control can at best be only roughly approximated. Individual differences extend over wide ranges in a variety of characteristics. Many psychological-sociological assumptions must be made: the system usually is very noisy; it is characterized by many nonrelevant and confounding inputs contributed to by both the individual (teacher or pupil) and his social-physical environments. Such conditions disrupt and interfere with the intended information getting through to the destination or the learner. Teacher or pupil information processing also is time-variant--i.e., it changes over periods of time-experience. It is highly adaptive to changing situations and conditions. And it may be considered autonomous (in that it possesses some degree of independence and self control), and self-regulating as well as self-programming.

In a gross and strictly conceptual sense, the pupil behavior goal toward which teacher information processing and pupil information processing alike are directed is:

1. Pupil acquisition of the defined information-behavior (i.e., sensing, identifying, and storing of facts, class concepts, and rules in the learner's existing information system)⁶ leading to association and integration of the information into the learner's hierarchical context⁷. This permits the pupil to extend his behavior repertoire--his information base of facts, principles, understandings, skills, procedures, behaving styles, sets, attitudes, etc., as they pertain to cognitive, affective, and motor behaviors.
2. Making such information behavior available for subsequent retrieval and application: (a) directly, essentially in its original form, in situations

⁶ Either through lower-level mediation--e.g., conditioned motor responses, memorizing of English-French vocabulary equivalents, etc.,--or through higher-level mediation--e.g., transfer of learning, learning by discovery, creative behavior, etc.

⁷ This includes gap filling or discovery of previously unrecognized information, as means of acquiring information.

similar to that in which the information was acquired; (b) for analogizing (transfer) and redintegration of information, in solving previously unencountered problems or adapting to novel situations; (c) for the mapping of associated information and its interrelationships, thus making explicit the information flow and system interactions, and revealing gaps leading to discovery of previously unrecognized information; and (d) for recombining and reorganizing information into new combinations, thus creating a previously unnoted concept or new behavioral product.

The ultimate goal of teacher information processing, and of all teaching, whether formal or informal, is assumed to be the development of individual student information-processing capabilities that will produce behavior which, throughout the life of the individual, permits the maximization of his own personal satisfactions and welfare, and also of his social productivity in the form of goods, services and attitudes.

SOME POSTULATES AND PROPOSITIONS
RELATING TO THE CONCEPTUALIZATION
OF TEACHER BEHAVIOR

Some Postulates

A number of assumptions or postulates regarding teacher behavior are involved in the theory of instruction presented here. The first six of these might apply to any conceptualization of teacher behavior and frequently have been stated by the writer in discussions of teacher behavior theory; the seventh refers specifically to the teacher as an information-processing system. These postulates, together with some of their implications, are:

I. Teacher behavior is characterized by lawfulness and order.

- A. Teacher responses, or teacher behaviors, cohere in sets or classes of interrelated behaviors, each class being characterized by a common substratum or core.
- B. Classes of teacher behaviors are characterized by some degree of stability or consistency.
- C. The phenomena of teacher behavior are logically related and it is possible to discover and describe the relationships, both those between antecedent and concomitant conditions and specified teacher behaviors, and also interrelationships between different teacher characteristics and classes of behaviors.
- D. When the characteristics of teachers, their antecedent and concomitant conditions, and their interrelationships are identified, teacher behavior may be predicted (at least, within limits imposed by the complexity and changing character of teaching situations).

- II. Empirical study and inductive inference (scientific induction) provide the valid approach to understanding of teacher behavior.
- A. Sampling theory is available and applicable, such theory including definitions of the concepts involved in sampling and descriptions of permissible operations applicable with different sampling models.
 - B. Applicable probability theory exists which provides the models with which empirical evidence relative to teacher behavior and pupil behavior can be compared and which permits the statement of inferences in probability terms.
 - C. Empirical data about teacher and pupil behavior can be assembled in accord with appropriate experimental designs, such designs serving to (1) focus observation on identifiable aspects of teacher behavior or teacher-pupil behavior, and (2) enhance, or at least permit knowledge of, the internal validity of the evidence (i.e., in the sense that contaminating effects are taken into account) and of its generalizability.
 - D. Sample data (C above) can be compared with probability models (B above) to obtain probability estimates which may be employed in arriving at inferences about the prediction of teacher behavior.
- III. Teacher behavior is observable.
- A. Classes or sets of teacher behaviors have distinguishing features which permit their identification and the differentiation of one behavior pattern from another in terms of the unique features which characterize each class.
 - B. Teacher behavior may be observed in both (1) samples and (2) correlates of verbal and motor teaching responses.
 - C. The conditions of observation of teacher behavior can be controlled (at least, to a reasonable degree) making comparability of assessments of teacher behavior possible.
 - D. Teacher behaviors are both qualitatively and quantitatively discriminable.
 - E. Teacher behavior can be observed and measured in a number of ways (e.g.: direct observation; indirect observation through use of a mediating test, inventory, or other device; observation of the behavior in process; observation of products of the behavior; observation of concomitants of the behavior; observation under natural conditions; observation under standard conditions).

- F. A particular class of teacher behaviors, or teacher behavior patterns, can be observed and measured relatively independently of other sets of teacher behaviors.
 - G. All measurements of teacher behavior are estimates; both (1) constant and/or systematic error and (2) variable error must be expected.
 - H. Regardless of variable conditions and imperfections in observational techniques, valid identification and measurement of teacher characteristics/behaviors is possible.⁸
- IV. Individual differences in observable teacher behavior exist.
 - V. Teacher behavior is basically social in nature.
 - VI. The end product of teacher behavior is some pupil behavior or set of pupil behaviors (i.e., teacher behavior consists of instrumental responses, or acts, on the part of the teacher, the objective of which is to influence the acquisition of pupil behavior of a specified kind and/or degree).
 - VII. Teacher behavior (and pupil behavior), both of which may be subsumed under a theory of instruction, can be described in terms of information processing or information systems.
 - A. Teacher behavior is instigated and determined by internal and external inputs to the teacher system, (e.g., (1) inputs and information-processing capabilities internal to the teacher: physical-physiological characteristics, general capabilities, characteristic abilities-capacities, characteristic behaving styles, characteristic affective sets, retrievable information stored in memory; (2) inputs external to teacher: objectives-goals of learning, pupil requirements, behavior/content to be learned by pupils, externally available information re behavior/content to be learned by pupil, learning aids or media available, pupil behavior in the learning situation, administrative policies, school law, etc., counseling-guidance to which pupil has been subjected, culture of which pupil is part, information and experience pupil brings to the learning situation.)

⁸ The designation and operational definition of the criterion variable and the development of estimating procedures which reflect the criterion variable comprise one of the most basic (and also one of the most neglected) aspects of behavioral research. The validity of evidence can be judged, of course, only when the nature of the criterion (i.e., dependent variable) has been adequately considered.

- B. Input processing (involving: sensing, decoding or perceiving; filtering and sifting; analyzing, transforming, and classifying; storing of potentially relevant information for ready utilization) is necessary to determination of the relevancy of available information for use in a given instructional situation.
- C. Relevant information available to the teacher is processed with respect to alternative adaptations and courses of action as a preliminary to decision-making about teacher behavior to be employed in a situation, (e.g., definition of goal in the given situation, analysis of information transmission task in situation; summary, synthesis, and recombination of relevant information; determination of alternative channels--teacher behaviors or combinations of teacher behaviors with the use of other learning aids and media; evaluation and prediction of probable outcomes of alternative courses of action; adoption of rules or bases for decision-making).
- D. Decision is reached with respect to instructional procedure/information forwarding in the given situation, (e.g., decision-making with respect to content to be transmitted to pupil including necessary adaptations and transformations; decision-making with regard to channels--mode of teacher behavior, media to be employed, etc.; decision-making with regard to preparation--i.e., prior information transmission--of pupil for receipt of the primary information; decision-making with regard to amount of information to be transmitted in the given situation; decision-making about the sequencing of information, i.e., preceding and following messages; decision-making with regard to evaluation, i.e., receipt of message and action upon it by pupil; decision-making about reinforcement of pupil behavior in response to message; decision-making with respect to control of noise, i.e., interfering inputs to pupil).
- E. Information output re teacher (i.e., teacher behavior) is programmed, preparatory to information exchange to pupil system, (e.g., information content is selected, encoded--adapted and transformed as required by situation--and readied for transmission; controls are designed; etc.).
- F. Teacher behavior, the output of the teacher system, is evoked which forwards information to the receiver/destination, i.e., the pupil.
- G. Information forwarded by the teacher and/or learning media reaches the receiver/destination, i.e., the pupil.
- H. Message is acted upon by pupil (and if successfully programmed, transmitted and received, is processed by the pupil system and incorporated into pupil's association hierarchy/storage for future retrieval, and/or produces an immediately observable response or pupil output).

- I. Feedback from the teacher behavior (i.e., teacher output) and the pupil behavior (i.e., pupil output) provides additional inputs permitting the consequences of the teacher behavior to modify future behavior in similar classes of teaching situations.

Some General Propositions

Two general propositions, really families of propositions, deducible from the stated definition of teacher behavior and postulates are presented.

Proposition I: Outputs of the teacher information system (i.e., teacher behavior, or teaching-related behaviors) comprise broad classes and patterns of interacting instrumental responses which, in turn, fall into the general categories of motivating-reinforcing, presenting-explaining-demonstrating, organizing-planning-managing, evaluating, and counseling-advising behaviors, these having as their goal the forwarding of information which will be incorporated into the pupil's hierarchy of skills, knowledge, understandings, attitudes, and other kinds of information/behavior.

Proposition II: Outputs of the teacher information system (i.e., teacher behaviors, or teaching-related behaviors) are functions of, and therefore vary with, the interaction of inputs in the form of (a) identifiable teacher characteristics and conditions, and (b) general and specific conditions of the teaching situation, including characteristics of the pupils taught, the administrative context, the cultural milieu, the learning content context, pupil behavior goals that have been set, feedback from the results of previous teacher behavior in similar teaching situations, and perhaps other conditions.

Each of these propositions has a number of ramifications or corollaries which need be considered in greater detail.

One important point that has been made is that teacher behavior consists of instrumental behaviors or responses. These instrumental behaviors of teachers are directed at, and are intended to lead to, the attainment of educational objectives which can be defined only in terms of specified pupil behaviors (knowledge, understandings, skills, attitudes, etc.). Teacher behaviors seldom can be considered ends in themselves; instead, they are means-to-ends behaviors that are intended to aid in achieving an end product consisting of specified behaviors and capabilities on the part of the teacher's pupils.

Motivating teacher behavior refers to information providing which is intended to maximize the degree to which the pupil-learner is set or oriented and ready

for the primary message or information to be conveyed. Often it involves making as certain as possible the learner is attending to the information transmission situation (i.e., to the directions and/or materials presented and presumed to be antecedents of his response). This may be thought of as implying the creation in the receiver/destination (i.e., the intended learner) of an appropriate state of anxiety--anxiety that will be relieved when the learner makes the correct response or otherwise effectively manifests receipt of, and action upon, the information (i.e., matches an agreed upon criterion of learning in that situation) and receives the reinforcement contingent thereto. Operationally, such motivating anxiety may be thought of simply as a condition in the learner which is followed by further learning activity. ("Appropriate state of anxiety" refers not to intense anxiety which may create a set or orientation for avoidance responses or for disorganized behavior, particularly when it is followed by failure to receive and interpret information successfully or failure to give the correct response. Rather, anxiety here refers to a condition of tension, uneasiness, or curiosity, which accompanies not knowing, or not being able to perform some act or not meeting a criterion, and which is relieved when the learner makes the kinds of responses stipulated by the teacher, textbook, or learning program.)

By reinforcing teacher behavior is meant teacher information-providing directed at the allaying of the learner's anxiety through the manipulation of rewards (e.g., comments, knowledge of results, etc.) when correct verbal or motor responses or solutions to problems are given, or when receipt of, and action upon, information is manifest in some other way. In this context, reinforcing conditions are any conditions either within the learner-system or external to him that presumably provide feedback and reduce anxiety--and which, then, tend to fix, or store, the behavior in the learner's hierarchical repertoire so it may be called up in the future by appropriate cues. Operationally, a reinforcing condition is simply any consequence of a response that is followed by increased probability of the response in a similar future situation.

Presenting-explaining-demonstrating teacher behavior refers to the forwarding of the primary or essential information upon which a particular teaching-learning situation is focused, i.e., to the information presumed to influence attainment of the educational objective or pupil behavior for which the teaching situation was planned. Presenting behavior involves making available the information in accordance with decisions reached prior to programming of teacher behavior for the information transmission. Explaining behavior has to do with information forwarding which has to do with interpretation and elucidation of the core information transmitted; in information theory terms it is an example of redundancy. Demonstrating teacher behavior is information forwarding where the message consists of a model, an example which shows some objects, its relationships, the operation of a principle, etc.

Organizing-planning-managing teacher behavior relates to the integration of information and methods of transmitting information to the pupil, together

with control of the information forwarding. Planning has to do with design of the information forwarding process. Organizing has to do with the arranging and programming of information forwarding behavior. Managing relates to the direction and control of the information forwarding process and the situation in which it has its setting. Organizing-planning-managing teacher behaviors include (a) arranging the content, materials, and directions so the information/learning content is at the appropriate level of difficulty for the learner, so information will be forwarded in appropriate-size steps, so it is adapted to the learner's current response repertoire, and so it is directed at appropriate operationally defined pupil behavior objectives (i.e., operationally defined knowledge, understandings, skills, attitudes, value systems, etc.), and (b) arranging information forwarding methods and aids adapted to the learning task, e.g.: demonstration; lecturing, opportunity for the learner to perform or make an active response; discussion; use of audio-visual aids, learning programs, TV, notebooks, textbooks, and other media; introduction of psychological principles of learning applicable to the particular learning task; etc.

Evaluating teacher behavior refers to the appraisal of the information forwarding process and of its effects on pupil behavior. As such, it involves activities which provide one source of feedback to both teacher and pupil. Evaluation may be formal in the sense that evaluation type information is collected and analyzed through systematic direct observation, content analysis, or the use of a test-inventory or some other device for measuring the amount of information transmitted, the information content, the receipt of information by a pupil (and its incorporation in his behavior repertoire), conditions such as sequencing, overloading, and redundancy, etc. Information evaluation is judgmental and may be engaged in by a teacher in a nonsystematic and irregular manner without measuring devices, and scales.

Counseling-advising teacher behavior involves the provision of information which either directs the recipient (i.e., pupil) or helps him organize his information base so he can discover guidelines and directions for himself. Its purpose is to facilitate information forwarding by providing rules and sets and orientations, and by supplying or generating information which will help remove blocks to the receipt of information and its incorporation in the pupil's repertoire.

Proposition II proposes that teacher behavior (i.e., teacher information processing) is contributed to in part by the teacher's personal and social characteristics (e.g., abilities and capacities, behaving styles, affective sets, etc.), which have their sources in both the genetic (unlearned) and experiential or past situational (learned) backgrounds of the individual. Knowledge of such characteristics contributes to the prediction, within limits, of a teacher's behavior in a given situation. Teacher behavior is also contributed to by general features of the teaching-learning situation in which the information has its setting--features which may be common to situations of a general class

and which, therefore, may be distinguished from the unique features of highly specific teaching situations. Information about such relevant general features of the situation aids in the prediction, within limits, of teacher behavior. Still further, teacher behavior is determined by unique features of the particular situation in which it has its setting at a particular time. Such features vary from situation to situation and contribute to the aspect of teacher behavior which is unique to a particular situation. Information about unique situational features may aid the prediction of teacher behavior; but such varying conditions often are difficult to identify beforehand and contribute to the unreliability of prediction--to the error term in prediction equations.

What Proposition II states, then, is that any phenomena relating to teacher behavior are functions of characteristics of the individual teacher (built-in and acquired) and situational factors (physical and social) operating at a given time, and that knowledge of (a) characteristics of the teacher and (b) the situational factors operating when a teacher behaves in a given way will permit the prediction (at least, within limits and with some anticipated error) of teacher behavior or teacher acts at another time when the conditions are approximately similar.

Research evidence, together with accumulated experience, suggests several major subpatterns of teacher behavior, which contribute to the motivating, presenting, organizing, evaluating, and advising behavior proposed as representing broad classes of teaching-related behaviors.⁹ Each subpattern represents a class of related teacher behavior dimensions, and each of these dimensions, in turn, appears to be reflected by a set of basic interacting or interrelated teacher characteristics.

Teacher characteristics and teacher behaviors may be postulated to form a hierarchy of classes. Relatively specific characteristics or behaviors which possess a common core form a more general class or dimension of teacher behavior,

⁹ A number of classes of teacher behaving styles have been noted in studies reported in the literature. Some of these focus upon the direct-dominative and indirect-integrated-permissive teacher-behavior patterns, some on the control of classroom emotional climate and classroom social structure, some on supportative vs. threatening teacher-behavior patterns, some on impulsive-cutspoken vs. self-controlling-orderly vs. fearful-anxious teacher behaviors, a number on friendly-warm, responsible-organized, and stimulating-imaginative teacher behavior patterns. A considerable amount of evidence has pointed toward several of these patterns of behaving styles. Figure 2 shows some of the common-appearing patterns of behavior reported by the Teacher Characteristics Study and supported by the findings of studies of other researchers. Similar summaries could be prepared relating to the other behaving styles mentioned in this footnote.

and these dimensions, in turn, combine with other dimensions possessing common elements to make up still more general behavior classes or patterns.

Specific teacher behaviors presumably could be highly situational and relatively unrelated among themselves, teaching, therefore, consisting of a very large number of largely independent acts or responses. But this does not provide a reasonable explanation, both because it is contrary to what is known of phenomena in other fields and particularly since general aspects of teaching-learning can be observed to be somewhat stable from situation to situation and from time to time. If there is some tendency for teacher behaviors to go together, or to be correlated, questions arise as to whether the correlation and overlapping is typical of all possible teacher behaviors (i.e., that they all contribute to some sort of general teaching ability) or if the interrelationships apply, at least at one level of generalization, to some limited number of groups, or clusters, of behaviors.

It seems reasonable to hypothesize, in light of studies of the organization of personality and behavior which have appeared during the past twenty or so years, that some of the designated teacher behaviors may be more closely intercorrelated than others and that the correlation matrix might suggest the possibility of a substantial reduction in a number of major dimensions required from the description of teacher behavior.

This was the approach taken in research conducted by the Teacher Characteristics Study (31) and the results seemed to bear out the line of reasoning. When separate intercorrelation matrices were generated for elementary school teachers and secondary school teachers and separate factor analyses carried out, three major patterns of teacher behavior (clusters or families of teacher behavior dimensions) emerged:

TCS Pattern X--warm, kindly, understanding, friendly vs.
aloof, egocentric, restricted teacher
behavior.

TCS Pattern Y--responsible, businesslike, systematic vs.
evading, unplanned, slipshod teacher
behavior.

TCS Pattern Z--stimulating, imaginative, surgent vs.
dull, routine, unimaginative teacher
behavior.

The hierarchical nature of TCS Pattern X may be observed from Figure 1. The descriptions appearing in the first column are taken from the Glossary used by trained observers. In the second column are descriptions employed on the observer's Classroom Observation Record. The pattern described in the third column was suggested by factor analysis.

It is of interest to observe that these teacher behavior patterns, TCS Patterns X, Y, and Z, are not entirely unique to the Teacher Characteristics Study, but

Operationally Definable and Observable Characteristic (manifest teacher behavior)	Inferred Behavioral Dimension	TCS Pattern of Teacher Behavior
Went out of way to be pleasant and/or to help pupils. Gave a pupil a deserved compliment. Showed affection without being demonstrative. Disengaged self from a pupil without bluntness, etc.	Harsh-Kindly Teacher Behavior	TCS Pattern X_0 : Kindly, understanding, friendly teacher behavior vs. Aloof, egocentric, restricted teacher behavior
Was hypercritical; fault-finding, Cross; curt. Depreciated pupil's efforts; was sarcastic. Lost temper. Used threats, etc.		
Approachable to pupil. Responded to reasonable request and/or question. Spoke to pupil as equal. Gave encouragement, etc.	Aloof-Responsive Teacher Behavior	
Stiff and formal in relations with pupil: Referred to pupil as "this child" or "that child," etc.		
Shown awareness of pupil's personal emotional problems and needs. Was tolerant of error on part of pupil. Patient with pupil beyond ordinary limits of patience, etc.	Restricted- Understanding Teacher Behavior	
Recognized only academic accomplishments of pupil; no concern for personal problem. Completely unsympathetic with pupil's failure at a task. Was impatient with pupil, etc.		

Figure 1.
Teacher Characteristics Contributing to a Behaving Style (31)

are supported not only by rationale based on consideration of the teaching process but also by reports of other factor analyses which have appeared in the literature. Figure 2 presents in summary some of these common appearing patterns.

(It will be noted from the comparison of studies that still another factor seems to cut across the several analyses--a pattern of teacher behavior which seems to relate to attractiveness--to what may be the stage appearance of the teacher or the extent to which he makes an impressive appearance.)

Actually, in the Teacher Characteristics Study research, nine variables or characteristics of teachers were studied. In addition to the TCS Teacher Behavior Patterns X, Y, and Z (reflected by observer's assessments and also by correlates of teacher behavior in the form of inventory responses) the Study concerned itself with the estimation of such characteristics as:

- Teacher Characteristic R--favorable vs. unfavorable opinions of pupils.
- Teacher Characteristic R1--favorable vs. unfavorable opinions of democratic classroom procedures.
- Teacher Characteristic Q--favorable vs. unfavorable opinions of administrative and other school personnel.
- Teacher Characteristic B--learning-centered (traditional) vs. child-centered (permissive) educational viewpoint.
- Teacher Characteristic I--superior verbal understanding (comprehension) vs. poor verbal understanding.
- Teacher Characteristic S--emotional stability (adjustment) vs. instability.

Such patterns as the kindly, understanding (X), responsible, businesslike (Y), and stimulating, imaginative (Z) teacher behavioral clusters would not be expected to retain their independence and be entirely discernible as higher orders or classes of teacher behavior are considered; nor would they be expected to be equally independent and apparent in different kinds of teaching situations or at different teaching levels. It would seem reasonable to hypothesize, for example, that Patterns Y and Z would be more apparent in the presenting behavior of a teacher than might Pattern X, and that Pattern X and Z might be more apparent in motivating teacher behavior than perhaps Pattern Y. This we do not know; but the hypotheses seem feasible. Figure 3 suggests a hypothetical hierarchical structure of teacher characteristics and behaviors. This chart is presented within the framework of the results and evidence reported by the Teacher Characteristics Study and therefore concentrates on the teacher behavior patterns that have to do with warm-friendly teacher behavior, systematic-responsible teacher behavior, stimulating-imaginative teacher behavior, and expressive-attractive teacher behavior. The heavier lines in each of these five sections of the chart are intended to suggest, hypothetically, the major contributing teacher behavior patterns (in terms of patterns identified by the Teacher Characteristics Study) contributing to each of the hypothesized forms of teacher behavior (e.g., presenting teacher behavior) which, either singly

or in combination contribute to the behavior of a particular teacher in a particular teaching situation. The lighter lines suggest less direct influences.

There is evidence from the Teacher Characteristics Study that among elementary teachers, the Patterns X, Y, and Z are highly intercorrelated; and all three seem to be highly correlated with pupil behavior in the teacher's classes. Among secondary school teachers, however, the intercorrelations of patterns are less high, the correlation between Pattern X (kindly teacher behavior) and Pattern Y (businesslike teacher behavior) being of a very low order; and the three teacher classroom behavior patterns are much less highly correlated with pupil behavior in classes of secondary teachers as compared with those of elementary teachers.

The results of several researches conducted in connection with the Teacher Characteristics Study suggest that understanding-friendly-sympathetic teacher behavior may be more in evidence among elementary school teachers, and that such behavior becomes increasingly less prominent as secondary school teachers and, next, college teachers, are considered. And the patterns referred to as organized-businesslike-systematic teacher behavior and stimulating-imaginative teacher behavior tend to become more prominent and apparently more important in teaching as observation of teaching is carried on at successively higher and more advanced educational levels, such as high school and college.

APPLICATION OF THE INFORMATION-SYSTEM MODEL TO THE INSTRUCTIONAL PROCESS

The terms "system analysis" and "system design" are frequently encountered in the literature. Analysis of a system is undertaken to (1) identify modes of interaction between the system's elements/subsystems and between the system and other systems in its environment, and (2) provide a starting point for research that may suggest new or modified designs of system organization and operation which will maximize the efficiency of the system's functioning. Thus, system analysis and design imply the (a) identification and operational definition of the objectives of the system, (b) identification and operational definition of the output, or outputs, (c) identification and operational definition of inputs, (d) design of observations to, insofar as possible, identify and operationally describe (or infer) the pertinent mediating conditions, components, and subsystems of the system, and (e) design of observations and analysis approaches which may lead to understanding of currently operating principles of the system which govern the interactions of mediating conditions and subsystems of the system with its external inputs. All of the preceding phases are directed at modification and rearrangement of components and operating principles (i.e., introducing potentially more effective, and eliminating less effective, operations) in order to more efficiently produce the output and achieve the objective or purpose of the system.

It is not difficult to see the advantages of considering teacher behavior and the instructional process in the system context. Such a model not only makes

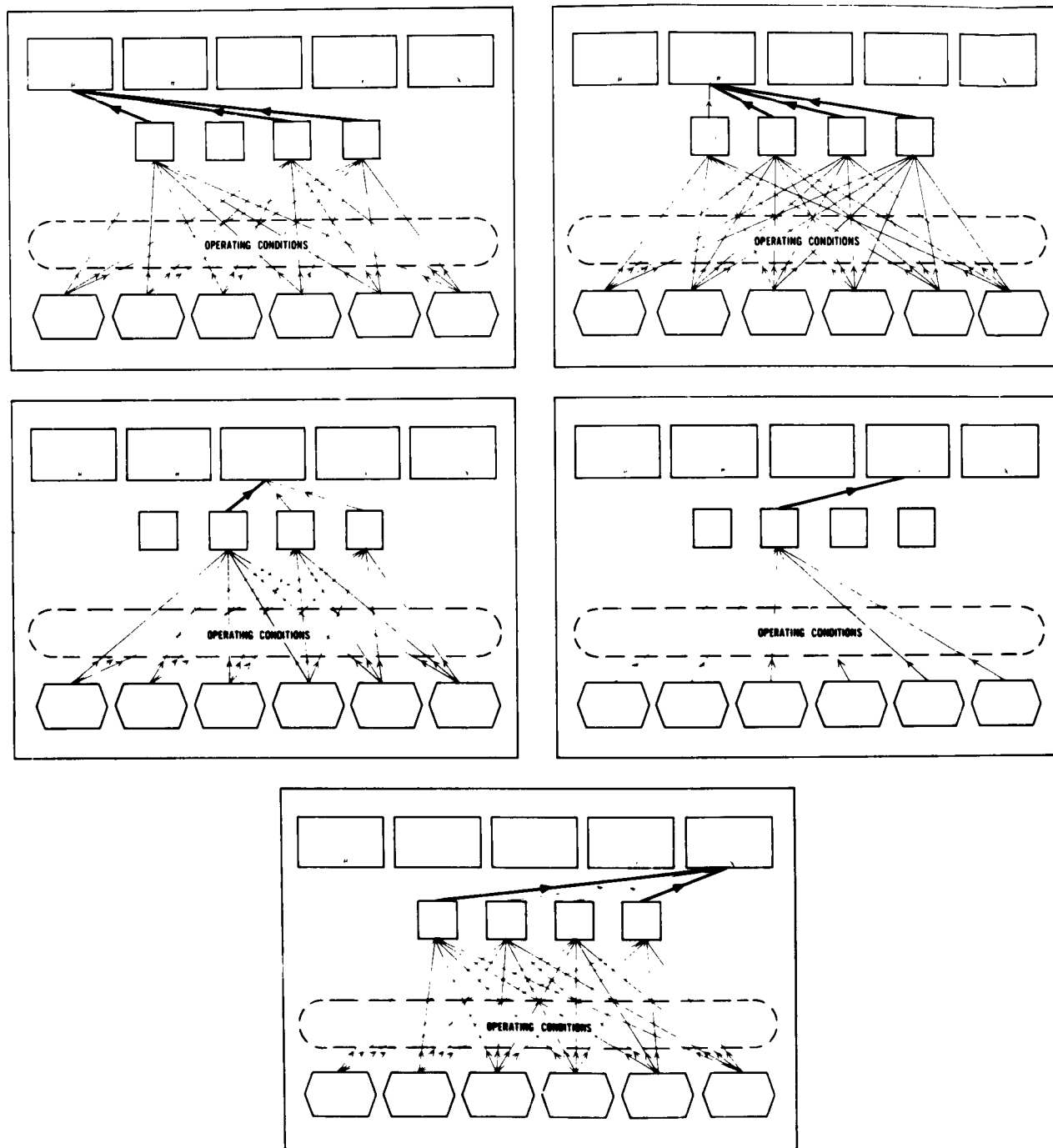
Population:	Elementary School; Secondary School Teachers ¹	College-University Teachers ²	Elementary Teachers ³	College-University Teachers ⁴	College-University Teachers ⁵	Forestry Service; Aircraft Industry Supervisors ⁶	College-University Teachers ⁷	General ⁸
Pattern X:	Friendly-Warm-Understanding vs. Aloof-Restricted	Sensitive-Sincere	Warm-Permissive	Empathetic	Friendly	Familiar	Rapport maintaining	Warm-Trustful vs. Impersonal-Aloof
Pattern Y:	Responsible-Organized-Businesslike vs. Unplanned-Slipshod	Well prepared-Efficient Presentations well organized	Concerned with student achievement-Systematic-Orderly	Well prepared-Instruction well organized	Business-like	Efficient		Dependable-Practical vs. Undependable-Impractical
Pattern Z:	Stimulating-Imaginative vs. Dull-Routine	Intellectually stimulating-Achievement motivating	Stimulating-Active	Empathetic (?)				Resourceful-Energetic vs. Stereotyped-Languid

Pattern E:	Attractive-Expressive vs. Unimpressive-Inexpressive	Personally acceptable (including appearance, speech)	Very verbal-Spends little time alone (?)	Acceptable appearing Verbally expressive	Communicative		Professionally impressing	

Figure 2.

Some Common-Appearing Patterns of Behavior Reported by Different Researchers

¹Ryans, D. G., Characteristics of Teachers, Washington, D. C.: American Council on Education, 1960.²Hodgson, T. F. and Horst, P., The general and primary factors in student evaluation of teaching ability. American Psychologist, 1959, 14, 374. (Abstract)³Travers, R. M. W., Wallen, N. E., Reid, I. E., and Wodtke, K. H., Measured needs of teachers and their behavior in the classroom. (H.F.W. Cooperative Research Program Contract No. 444-8029.) Salt Lake City: University of Utah, 1961.⁴Coffman, W. E., Determining students' concepts of effective teaching from their ratings of instructors. Journal of Educational Psychology, 1954, 45, 277-86.⁵Gibb, C. A., Classroom behavior of the college teacher. Educational and Psychological Measurement, 1955, 15, 254-63.⁶Comrey, A. J., High, W. D., and Goldberg, L. L., Factorial dimensions of organizational behavior, I: field service workers. Educational and Psychological Measurement, 1955, 15, 225-35. Factorial dimensions of organizational behavior, II: aircraft workers. Educational and Psychological Measurement, 1955, 15, 371-82.⁷Creager, J. A., A multiple factor analysis of the Purdue rating scale for instructors. Studies in Higher Education (Purdue University), 1950, 70, 75-96.⁸Cattell, R. B., Description and measurement of personality, Yonkers, N. Y.: World Book Co., 1946 (and subsequent publications).

**FIGURE 3**

Hypothetical Hierarchical Structure of Teacher Characteristics and Teacher Behavior Patterns Contributing to Teacher Behaviors

explicit the information forwarding nature of instruction but also provides a general methodology for analyzing and improving teaching-learning.

The discussion which follows will consider teacher behavior (and pupil behavior) from the standpoint of the definitions, postulates, and general propositions that will provide the background for the theoretical position presented here.

Some Explication of the Basic Position

- 1 The individual teacher (similarly, the individual pupil; also, the teacher-pupil combination) constitutes an open, self-organizing and self-regulating system. As an open system teacher functioning, and pupil functioning is modifiable, or subject to change. The system is capable of "learning" from experience; and it is self-organizing/self-regulating to the extent it can make decisions and translate them into action in adapting to the exigencies of the situation.
2. Teacher behavior (and similarly pupil behavior) considered with this information system context is an output, representing outgoing exchange of energy/information across the boundary of the teacher-system--and consequently resulting in some alteration of energy form. Teacher behavior, an output of the teacher-system is intended to be an input for pupil systems, i.e., to influence, or contribute to the purported product of teacher information processing, pupil behavior.

The outputs with which teacher behavior theory is principally concerned are coded outputs. They are nonrandom and convey information or meaning. A coded output of the teacher serves as a coded input for the pupil and is instrumental in eliciting an output from the pupil system (i.e., pupil behavior of a predictable sort). Coding thus involves the programming of an output of the teacher system so information is conveyed and pupil behavior specified by the goal or objectives of the teaching will result. Of course, while the meaningful, pupil-goal-directed behavior of the teacher is of primary interest, teacher outputs which may constitute noise and which, because of their random and non-goal-directed nature may serve to distract the learner and to impede learning, can not be ignored. The purpose of all instruction is to maximize information conveyed in the teaching situation and minimize distracting and interfering conditions.

The major classes of outputs of the individual teacher-system, either verbal or nonverbal, are, as previously noted, the manifest or observable motivating, presenting, organizing, evaluating and counseling teacher behaviors. The major classes of outputs of the individual pupil-system are the manifest pupil knowledge, understanding, skills, attitudes, etc.

The over-all function of the teacher system is to transform energy/information and transmit it to learners or pupils in consumable or meaningful forms.

Thus, an important aspect of teacher behavior involves the processing of information in the supra-set or supra-system in which both teacher and pupils are central elements (i.e., the teaching-learning system represented by the classroom). What goes on in the teacher-system, in the pupil-system, and in the teacher-pupil system constitutes the essence of the interest of professional educators and educational psychologists. This information processing usually will not be readily available for direct observation and often can only be inferred.

3. The output of the teacher information system, teacher behavior, is a function of two classes of inputs: inputs in the form of behavior capabilities and characteristics of the teacher; and inputs from the external environment.

Some of the major classes of internal inputs to the information processing engaged in by the teacher appear to be:

- a. physical-physiological characteristics of the teacher, including organic state at any given time (t_{ppc});
- b. general capabilities of the teacher, e.g., sensory-perceptual capacities, memory and recall capacities, plasticity, responsivity (t_{gc});
- c. abilities and capacities, e.g., verbal, quantitative, psychomotor, logical, etc., (t_{ac});
- d. behaving styles, e.g., personal-social patterns of response (t_{bs});
- e. affective sets, e.g., attitudes, values orientation, temperamental-emotional characteristics, etc., (t_{as});
- f. retrievable information, e.g., cognitive, affective, and motor information/behavior incorporated in teacher's association hierarchy (t_{ri}).

These teacher capabilities and characteristics which serve as inputs to teacher behavior are, in turn, hypothesized to be contributed to by genetic and experiential conditions or inputs:

- i. built-in genetic characteristics (t_g);
- ii. the past-situational context of teacher education, or teacher training, to which the teacher has been exposed ($t_{ps_{ed}}$);
- iii. the past-situational incentive or motivational context in which the teacher has developed, i.e., previously acquired incentives and drives (t_{ps_m});

- iv. the home background of the teacher (t_{ps_h});
- v. the past-situational, general and specific, cultural and community contexts in which the teacher has developed ($t_{ps_{cul}}$);

Some of the major classes of situational conditions or external inputs to teacher information processing which may be hypothesized to influence teacher behavior at any given time are:

- a. the pupil behavior context within which the teacher currently is carrying on his teaching functions (s_{pb});
- b. the administrative context (policies of the state, school district, particular school, etc.) in which the teaching currently is performed (s_{ad});
- c. the cultural context (geographical, political, temporal, peer group, etc.) in which the teacher currently is carrying on his teaching activities (s_{cul});
- d. the pupil behavior goal context--i.e., pupil behavior toward which the instruction is directed ($s_{pb_{lm_g}}$);
- e. the learning-materials context (learning content in the form of attitude, skill, knowledge, etc.) involved in the teaching behavior ($s_{lm_{co}}$);
- f. the learning-materials media or aids context (learning media and aids available to the teacher) in which the teaching is carried out (s_{lm_a});
- g. the counseling-guidance context to which the pupils in the teacher's class have been exposed ($s_{pb_{cg}}$).

One set of inputs to teacher behavior, feedback inputs which derive from the consequences of other teacher behaviors (teacher system outputs), deserve independent mention. The teacher as an open system and teacher behavior as an output of the teacher system is modifiable by the influence of its effects. Both teacher behavior itself and pupil behavior following teacher behavior provide feedback inputs which regulate, control, and modify subsequent teacher information processing.

- 4. The basic elements, or subsystems, from which teacher behavior is compounded are teacher characteristics, or teaching-related traits of an individual.

The concept of "teacher characteristics" may be most easily and explicitly defined in terms of an abstract model taking the form of an equation--Equation I.

Models of the sort represented by the equations presented here are abstract-- and they necessarily are tentative. In employing this form of description, there is no intention of stating all of the parameters that may be involved. The components of such equations are largely inferred. Knowledge of how the components interact and combine is generally unknown. It seems certain that interaction of the variables occur, in addition to reactive and main effects of such variables as do indeed enter into the picture. A large error component (error being used in a broad sense to include all sources of unidentified or uncontrolled variation--i.e., sampling error and observation error) is involved.

Whether the components combine in an additive or multiplicative fashion is not known; the combinatorial operation therefore is designated in the equations employed as models merely by a comma between components.

Models of this sort are tentative and subject to revision. Furthermore, they state only the general variables which appear to the theorizer to operate; submodels or subequations are required to elucidate each of the components in greater detail.

As others have pointed out in suggesting abstract models of behavior, an equation of this sort is intended simply as a statement of hypothesized lawful relations for which the parameters and functional relationships (curve forms) are not yet known. But such models do provide a starting point for conceptualizing and focus attention on specific questions and problems that otherwise might not be formulated.

Equation I, following, is presented as an attempt to define the concept "teacher characteristic," which we may consider a foundational building-block or subsystem of behavior which contributes directly to more molar forms of teacher behavior.

Equation I

$$tc_{n_i} = f \left[(t_{\bar{g}_{n_i}}), (t_{\overline{ps}_{n_i}}), (e) \right]$$

where

- (a) tc_{n_i} = teacher characteristic n (a teaching-related trait) of teacher i (which may be a component of tbp_{n_i}) teacher behavior

pattern n of teacher i--and a component of tb_{ij} , the behavior of teacher i in situation j).¹⁰

$$(b) \quad tg_{ni} = t_{g_{1i}}, t_{g_{2i}} \dots t_{g_{ni}}$$

t_{g_i} represents the genetic context, or sum total of teacher i's genetic background contributing to characteristic n.

$t_{g_{1i}} \dots t_{g_{ni}}$ represent components of teacher i's genetic background.

$$(c) \quad t_{ps_{ni}} = t_{ps_{ed_i}}, t_{ps_{m_i}}, t_{ps_{h_i}}, t_{ps_{cul_i}}, \dots e.$$

$t_{ps_{ni}}$ represents the past-situation (experiential) context or sum total of teacher i's past experience which contributes to characteristic n.

$t_{ps_{ed_i}}$ represents teacher i's education or training context (including both formal education and informal education gained from experience), and $t_{ps_{ed_{1i}}} \dots t_{ps_{ed_{ni}}}$ represent components of teacher i's training or education and teaching experience.

$t_{ps_{m_i}}$ represents the incentive and motivational context of teacher i, and $t_{ps_{m_{1i}}} \dots t_{ps_{m_{ni}}}$ represent motivational

¹⁰ tc_{ni} may be any behavior capability or characteristic of teacher i (i.e., a physical-physiological characteristic; a general capability such as the capability for sensing and perceiving inputs or for modification of behavior; a characteristic ability or capacity such as verbal, quantitative, or logical ability; a behaving style; an affective set such as a class of attitudes or values; behavior involved in retrieving information relevant for a teaching situation (see lower portion of Figure 4).

components (including: teacher i's perception of the stereotype or image of the teacher; incentives which reinforce teacher i's behavior, both incentives peculiar to teacher i and those shared in common with other teachers; other reinforcing conditions re teacher i's behavior; teacher i's persistence and drive; etc.).

$\overline{t_{ps_{h_i}}}$ represents the home background of teacher i, and

$t_{ps_{h_{1_i}}} \dots t_{ps_{h_{n_i}}}$ represent components of teacher i's home background--both early and more immediate home conditions.

$\overline{t_{ps_{cul_i}}}$ represents the cultural (including community and peer group) context of teacher i, and $t_{ps_{cul_{1_i}}} \dots t_{ps_{cul_{n_i}}}$

represent cultural aspects or components--both early and more immediate cultures of teacher i.

e = error component.

Thus, an alternative manner of writing Equation 7 would be:

$$t_{c_{n_i}} = f \left[(t_{g_{1_i}} \dots t_{g_{n_i}}), (t_{ps_{ed_{1_i}}} \dots t_{ps_{ed_{n_i}}}), \right. \\ (t_{ps_{m_{1_i}}} \dots t_{ps_{m_{n_i}}}), (t_{ps_{h_{1_i}}} \dots t_{ps_{h_{n_i}}}), \\ \left. (t_{ps_{cul_{1_i}}} \dots t_{ps_{cul_{n_i}}}), (e) \right]$$

5. Teacher characteristics that have features in common with certain other teacher characteristics form (as a result of their interrelatedness) general classes of teacher system outputs which possess the property of dimensionality, permitting judgments of more than or less than with respect to such first order dimensions of teacher behavior (e.g., kindly-harsh behavior, responsive-alloof behavior, fair-partial behavior, original-stereotyped behavior, stimulating-dull behavior, responsible-evading behavior,

systematic-disorganized behavior, etc.). These teacher behavior dimensions, in turn, form families or classes (intercorrelated dimensions which are identifiable through factor analysis) which possess considerable generality from situation to situation in the teaching context. Such major clusters of teacher behavior dimensions are arbitrarily referred to as patterns of teacher behavior (tbp). Some of the common patterns, or general classes of teacher behavior that have been identified have been noted on pages 22-25

The concept of "teacher behavior pattern," as it may apply to teacher i , may be defined by an equation similar to Equation II, following:

Equation II.

$$tbp_{n_i} = f(tc_{n_{1_i}} \dots tc_{n_{n_i}})$$

Equation IIa applies to TCS Pattern X and indicates that the pattern is comprised of a number of teacher characteristics which, in light of common elements, are characterized by interrelatedness.

Equation IIa

$$tbp_{X_i} = f(tc_{X_{1_i}} \dots tc_{X_{n_i}})$$

where:

tbp_{X_i} represents the understanding, friendly, teacher behavior of teacher i , and $tc_{X_{1_i}} \dots tc_{X_{n_i}}$ represent the interrelated teacher characteristics contributing to the general class of understanding, friendly, teacher behavior (i.e., dimensions which, in light of their interrelatedness, form the major class of teacher behavior tbp_X with respect to teacher i).

6. The behavior of a teacher (e.g., teacher i) in a particular teaching situation (situation j) is a function, or resultant, of the main and interaction effects of the inputs noted on pages 32-33.

An abstraction which specifies the interacting conditions which may contribute to the behavior of teacher i in situation j are shown in Equation III which follows.

Equation III

$$tb_{ij} = f \left[(tbp_{1i} \dots tbp_{ni}), (\overline{s_{pb_{1j}}} \dots \overline{s_{pb_{nj}}}), (s_{ad_{1j}} \dots s_{ad_{nj}}), \right. \\ (s_{cul_{1j}} \dots s_{cul_{nj}}), (s_{lm_{co_{1j}}} \dots s_{lm_{co_{nj}}}), (s_{lm_{a_{1j}}} \dots s_{lm_{a_{nj}}}), \\ \left. (s_{pb_{lm_{g_{1j}}}} \dots s_{pb_{lm_{g_{nj}}}}), (tb_{fb_i}), (e) \right]$$

where:

tb_{ij} = the instrumental behavior (phenotypical) of teacher i in teaching situation j.

$tbp_{1i} \dots tbp_{ni}$ = teacher behavior patterns of teacher i as defined by Equation II.

$\overline{s_{pb_{1j}}} \dots \overline{s_{pb_{nj}}}$ = a current situation condition represented by the sum total of behaviors of pupil 1...pupil n (i.e., the group or class of pupils participating) in teaching situation j; and where pb_{nj} , or $pb_{n(lm_{cc})_j}$, is defined as the sum total of behaviors of individual pupil n in learning situation j.

$s_{ad_{1j}} \dots s_{ad_{nj}}$ = current situational conditions represented by administrative policies, controls, directions, etc., which must be taken into account in situation j.

$s_{cul_{1j}} \dots s_{cul_{nj}}$ = current situational conditions represented by cultural factors (representing values and attitudes of community, geographic division, political division, peer group, era, etc.) which bear on situation j.

$s_{lm_{co_1j}} \dots s_{lm_{co_nj}}$ = current situational conditions represented by the learning materials content (e.g., knowledge, understanding, attitudes, skills, processes to be learned--both reflecting and helping to define the pupil behavior goal or objective) in situation j.

$s_{pb_{lm_{g_1j}}} \dots s_{pb_{lm_{g_nj}}}$ = current situational conditions represented by pupil behavior goals or objectives in situation j.

tb_{fb_1} = sum total of feedback resulting from behavior of teacher i in previous teaching situations having elements in common with situation j.

e = error.

Teacher behavior, as defined by Equation III could be more definitively written with specification of (a) the group or subpopulation of teachers of which the teacher (i.e., teacher i) is a member, (b) the general class of teacher instrumental responses involved, and (c) the general class of pupil goal behaviors toward which the teaching is directed. For example, if:

$T_\alpha, T_\beta, T_\gamma, T_\delta$, etc., represent particular teacher subpopulations with respect to which teacher behavior may be expected to vary (e.g., T_α = English teachers; and t_{α_1} a particular English teacher i).

Tb_μ represents motivating teacher behavior and tb_{μ_j} a particular motivating behavior in situation j;

Tb_π represents presenting teacher behavior and tb_{π_j} a particular presenting behavior in situation j;

Tb_o represents organizing teacher behavior and tb_{o_j} a particular organizing behavior in situation j;

Tb_e represents evaluating teacher behavior and tb_{e_j} a particular evaluating behavior in situation j;

Tb_{χ} represents counseling-advising teacher behavior and tb_{χ_j} a particular counseling behavior in situation j ;

Pb_{lm_g} represent pupil behavior goal re specified learning content and $pb_{lm_g_j}$ a particular pupil behavior goal in situation j .

Using these terms, Equation III might be written as follows if teacher i was an English teacher engaged (in situation j) in presenting behavior (π), directed at pupil behavior goal n .

$$tb_{\alpha_i}(tb_{\pi} \rightarrow pb_{lm_{g_n}})_j = f \left[(tb_{p_{1_i}} \dots tb_{p_{n_i}}), (s_{pb_{1_j}} \dots s_{pb_{n_j}}), \right. \\ (s_{ad_{1_j}} \dots s_{ad_{n_j}}), (s_{cul_{1_j}} \dots s_{cul_{n_j}}), \\ (s_{lm_{co_{1_j}}} \dots s_{lm_{co_{n_j}}}), (s_{lm_{a_{1_j}}} \dots s_{lm_{a_{n_j}}}), \\ \left. (s_{pb_{lm_{g_{1_j}}}} \dots s_{pb_{lm_{g_{n_j}}}}), (tb_{fb_i}), (e) \right]$$

7. The over-all teacher behavior of teacher i across a variety of teaching situations (an abstraction, and little more; nevertheless, something frequently referred to when people discuss individual teachers and attempt to evaluate them) may be thought of as the resultant of the motivating, presenting, organizing, evaluating, and counseling behavior of teacher i , interacting with the various situational conditions referred to in Equation III.

Thus, we might describe the over-all teacher behavior of teacher i , in terms of our model, as:

Equation IV

$$\overline{Tb}_i = f \left[(\overline{tb}_{u_i}, \overline{tb}_{\pi_i}, \overline{tb}_{o_i}, \overline{tb}_{e_i}, \overline{tb}_{\chi_i}), (\overline{p}_{1_i}), (\overline{Ad}), \right. \\ \left. (\overline{Cul}), (\overline{lm}_{co}), (\overline{lm}_a), (\overline{pb}_{lm_g}), (tb_{fb_i}), (e) \right]$$

where:

$\overline{Tb}_1$ = an abstraction representing the over-all teacher behavior of teacher 1 in a variety of teaching situations;

$\overline{tb}_\mu$, $\overline{tb}_\pi$, $\overline{tb}_o$, $\overline{tb}_\epsilon$, and $\overline{tb}_\chi$ = sum total, respectively, of the motivating, presenting, organizing, evaluating, and counseling behavior of teacher 1 across a variety of teaching situations; and

$\overline{Pb}_1$, $\overline{Ad}$, $\overline{Cul}$, $\overline{Lm}_{co}$, $\overline{Lm}_a$, $\overline{Pb}_{lg}$, $\overline{Tb}_{fb_1}$ = the sum total, respectively, of pupil behavior in classes teacher 1 is teaching or has taught, administrative policies, cultural influences, learning materials content, learning materials aids, pupil behavior goals re learning materials in light of which teaching behavior is carried out, and feedback resulting from teacher 1's behavior in other teaching situations.

Equation IV could be still more definitively written with respect to teacher 1, if teacher 1 were, let us say, an English teacher, as:

Equation IVa

$$\overline{Tb}_{\alpha_1} = f \left[(\overline{tb}_{\alpha_1(\mu)}), (\overline{tb}_{\alpha_1(\pi)}), (\overline{tb}_{\alpha_1(o)}), (\overline{tb}_{\alpha_1(\epsilon)}), (\overline{tb}_{\alpha_1(\chi)}), \right. \\ \left. (\overline{Pb}_1), (\overline{Ad}), (\overline{Cul}), (\overline{Lm}_{co_\alpha}), (\overline{Lm}_{a_\alpha}), (\overline{Pb}_{lg_\alpha}), \right. \\ \left. (\overline{tb}_{fb_1}), (e) \right]$$

where:

$\overline{Tb}_{\alpha_1}$ represents the abstract, over-all teaching related behavior of English Teacher 1; $\overline{tb}_{\mu_1}$, $\overline{tb}_{\pi_1}$, $\overline{tb}_{o_1}$, $\overline{tb}_{\epsilon_1}$, and $\overline{tb}_{\chi_1}$ represent the over-all motivating, presenting, organizing, evaluating, and counseling behaviors of English teacher 1; $\overline{Pb}_1$, $\overline{Ad}$, $\overline{Cul}$ represent respectively the pupil behavior context to which teacher 1 is and

has been exposed, the administrative policies and practices context, and the cultural context in which the teaching is conducted;

Lm_{co_α} , Lm_{a_α} , and $Pb_{lm_{e_\alpha}}$ represent the sum total, respectively, of learning materials content in the English domain, available learning material aids relative to the English content, and the pupil behavior goals relative to the English learning material content; and $Tb_{\overline{Tb}_1}$ represents the sum total of feedback.

8. The abstraction could be carried still further by attempting to define teacher behavior in general--the concept of the "teacher behavior of all teachers across all teacher situations," assuming any defined population of teachers and teaching context (e.g., teachers teaching public schools in the State of California in 1960). The abstraction "teacher behavior" then becomes the resultant of the combined individual teacher behaviors of all teachers.

Equation V

$$\hat{Tb} = f(\overline{Tb}_1 \dots \overline{Tb}_n)$$

where:

$\hat{Tb}$ represents teacher behavior in general, an abstraction relating to all teachers, across all situations (assuming a specified teacher population).

The propositions which have been stated at some length in this section are summarized in Figure 4 which follows.

Figure 4 attempts to model in a diagram the principal direct inputs to the teacher-system and to indicate possible interactions that may occur as the teacher programs those inputs and possible outputs, or ways of behavior, to evolve the teacher behavior in a given situation. The inputs include, of course, the various classes of teacher characteristics, as well as the situational inputs which help to determine teacher behavior in a teaching-learning situation. Particularly important in this systemic account of teacher behavior are the feedback inputs which originate as teacher outputs/behaviors and the effects of those outputs, and as a part of the teacher's past situational repertoire may result in modification of future teacher behavior in a similar situation. The output of the teacher behavior, is presumed to serve its major role as an input for pupil behavior. Figure 4 (supported by Figure 5) capsules the elementary theory of teacher behavior presented here.

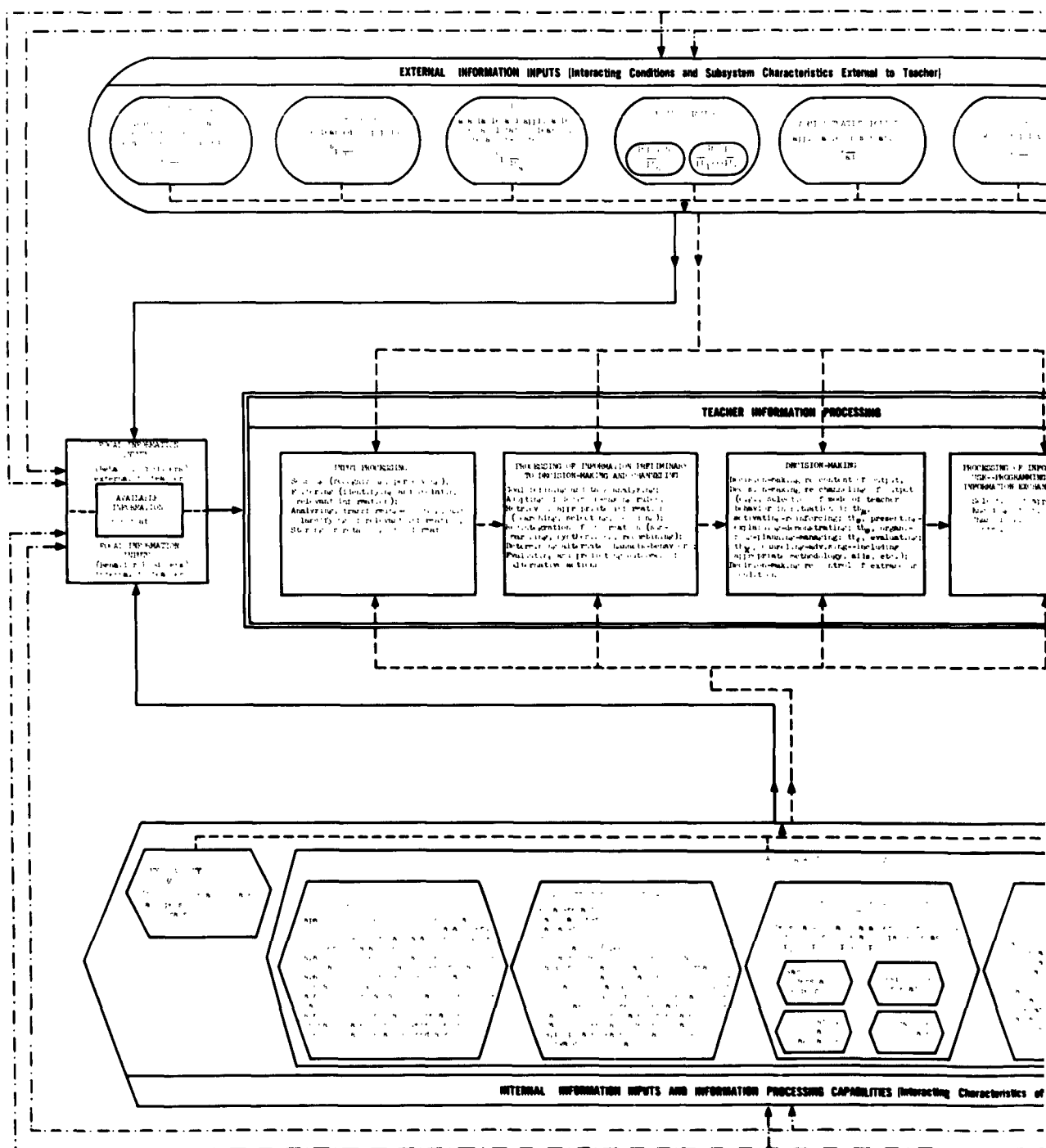


FIGURE 4

Teacher Information Processing System Culminating in Teacher Behavior (10)

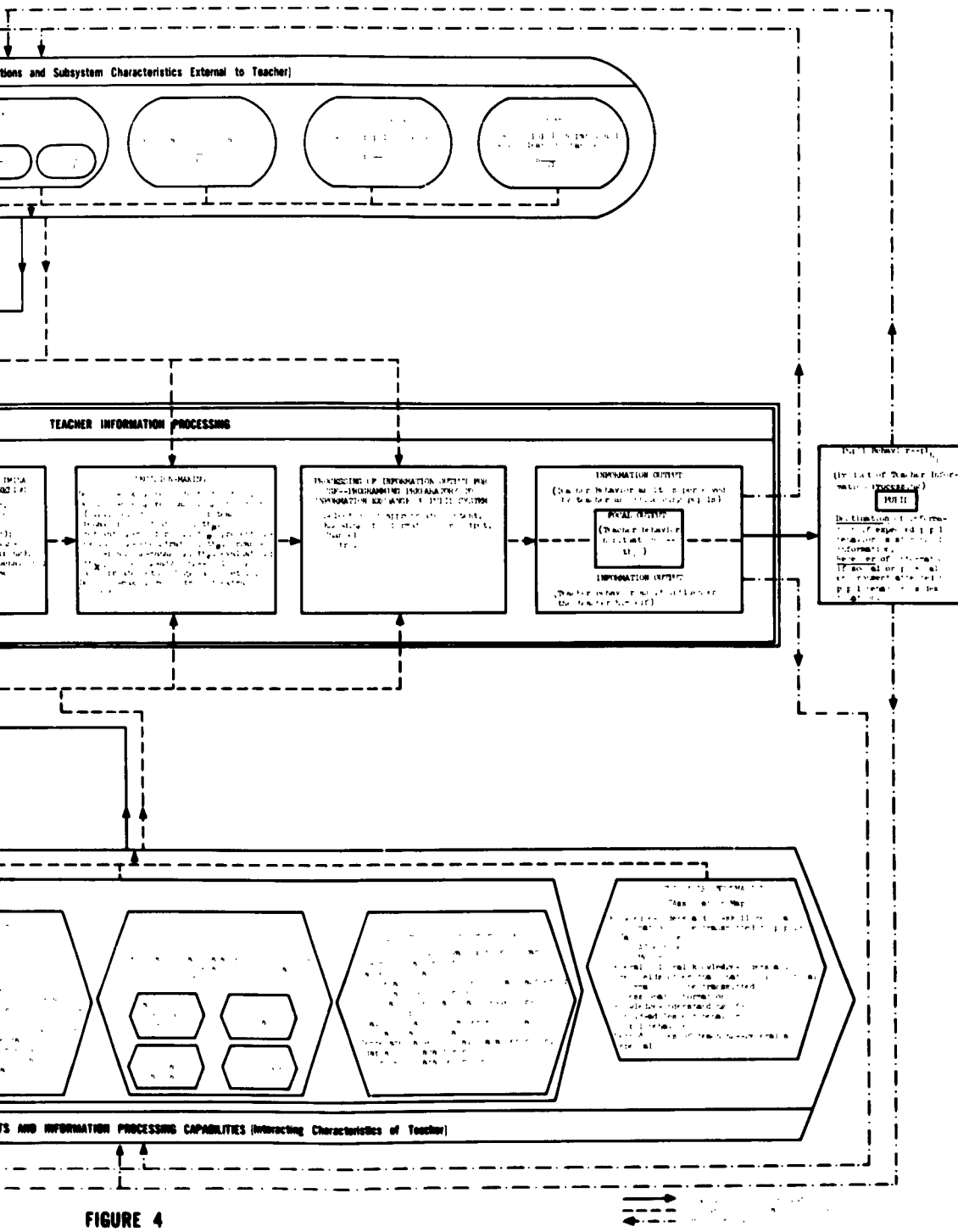
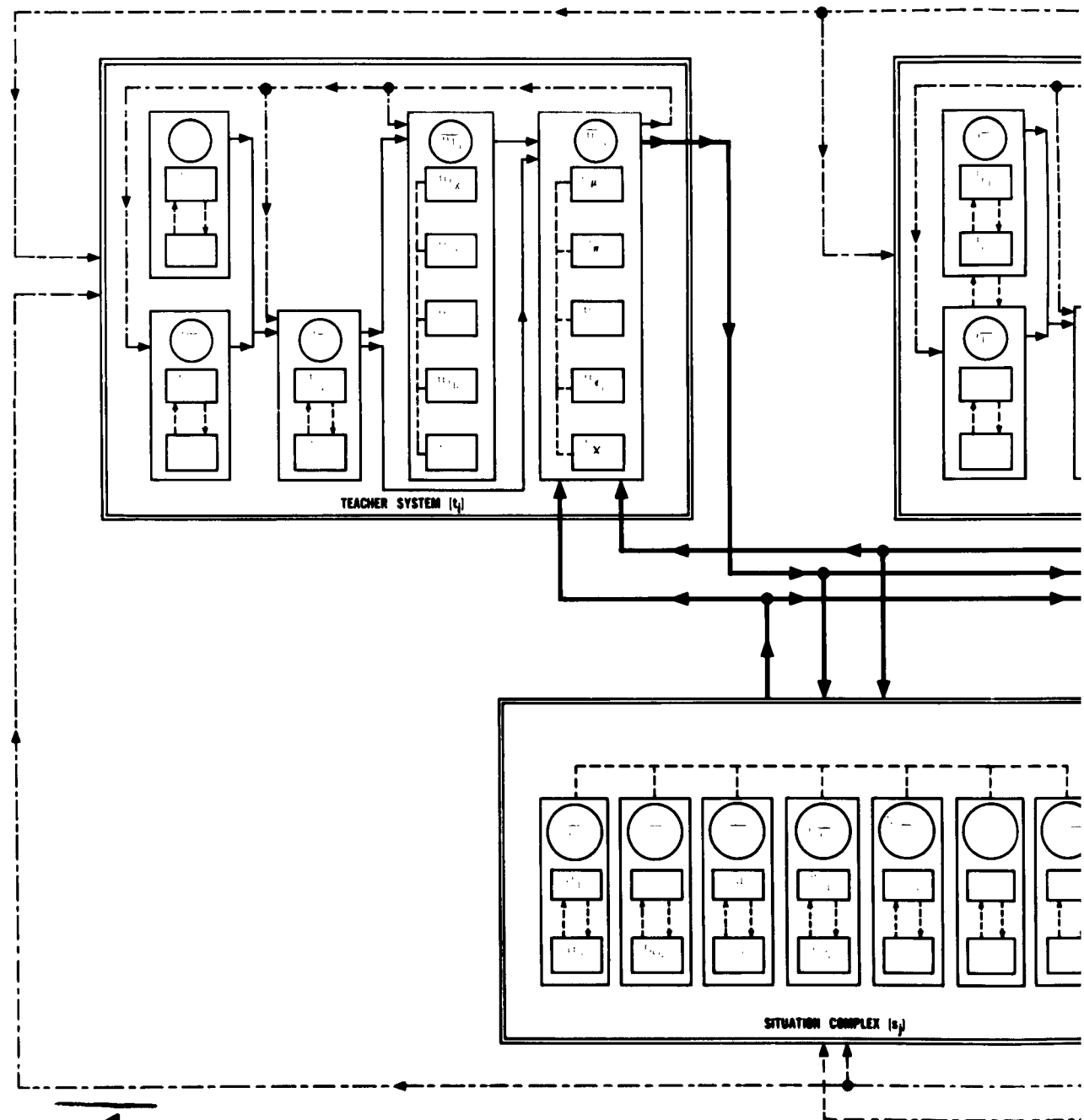


FIGURE 4

Information Processing System Culminating in Teacher Behavior ($I b_1$)

**FIGURE 5**

Schematic Representation of Hierarchical Nature of Teacher and Pupil Behavior Systems
and of Interactions of Pupil-Teacher-Situation in Pupil Learning in the School

1

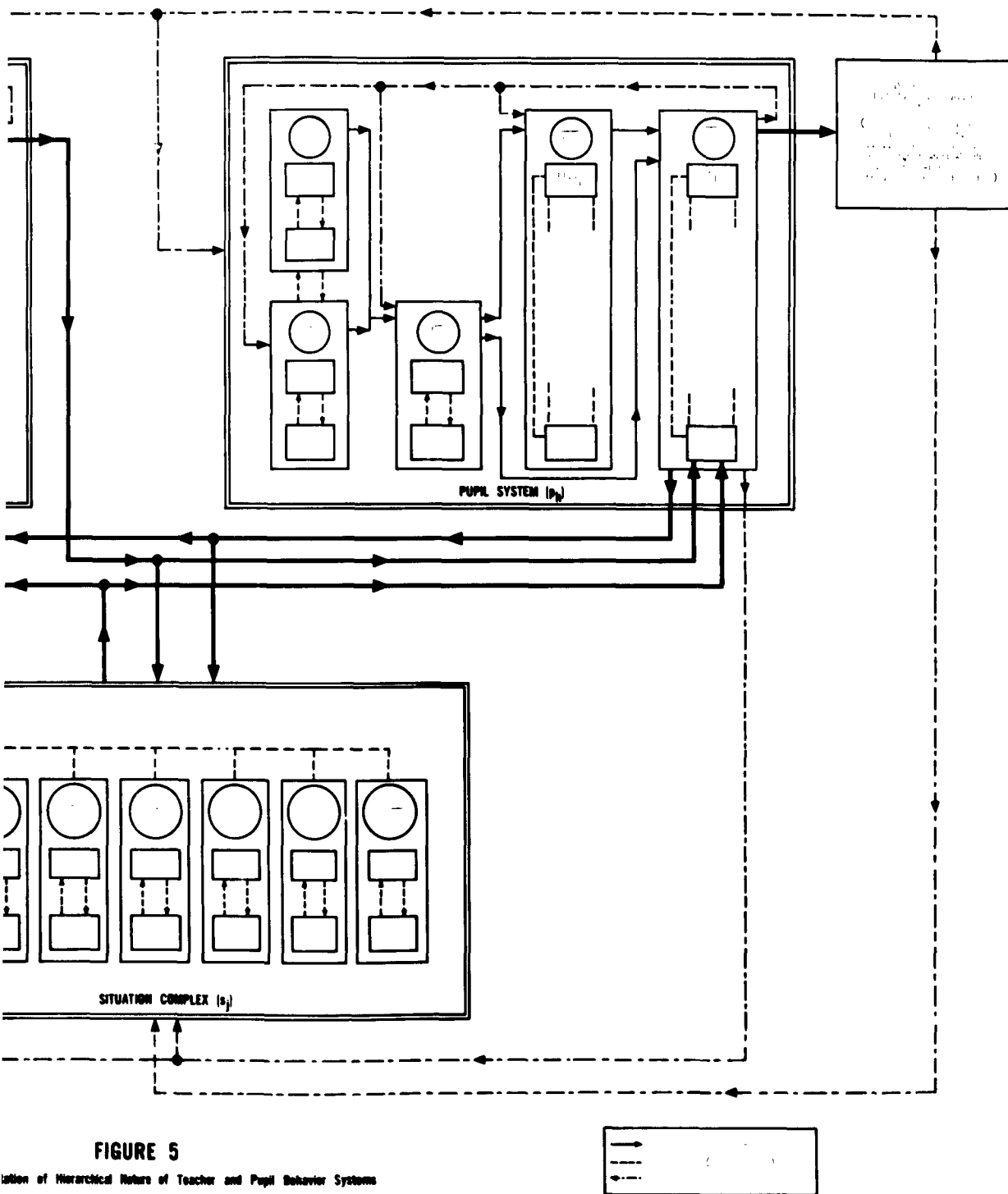


FIGURE 5

Diagram of Hierarchical Nature of Teacher and Pupil Behavior Systems
Flow of Pupil-Teacher-Situation in Pupil Learning in the School

The principal purpose of Figure 5 is to model diagrammatically the equations presented in the immediately preceding paragraphs, showing how teacher behavior in a particular situation, and pupil behavior in that situation, are built up, respectively, from teacher and pupil characteristics. Perhaps the most important feature of Figure 5 is to show how teacher behavior, pupil behavior, and the various conditions which contribute to the situation complex, (including the important goals which direct teacher and pupil behavior) interact and are inextricably associated in the teaching-learning process. Figure 5 emphasizes the multifaceted and hierarchic organization of teacher behavior.

Notes on Pupil Behavior

Lest too much be expected of the teacher in producing pupil behavior, it is proper to note that teacher behavior is only one of a complex of conditions which contribute to pupil behavior.

The behavior of a pupil (pupil h) in a particular situation (situation j), may be conceptualized as a resultant of:

1. teacher behavior in the particular situation (tb_{1j}),--the behavior of teacher 1 in situation j ;
2. pupil characteristics of pupil h , ($pc_{1h} \dots pc_{nh}$) forming whatever the appropriate patterns of major variables of pupil behavior may be (e.g., general and specific abilities, sex, age, behaving styles, affective sets, retrievable information, etc., of pupil h);
3. the learning material content characterizing situation j and to which pupil h is exposed; ($s_{pb_{lm}co_j}$);
4. the learning material aids to which pupil h is exposed in situation j ; ($s_{pb_{lm}a_j}$);
5. the pupil behavior objectives or goals toward which teaching in situation j is directed ($s_{pb_{lm}g_j}$);
6. the school's administrative policy and practices relevant to situation j (s_{ad_j});

7. the counseling-guidance to which the pupil has been exposed and which is relevant to situation j (pb_{cg_h});
8. the cultural context (community, geographic, economic, psychological, political, temporal) in which the teaching situation j is conducted (s_{cul_j});
9. feedback from previous behavior (pb_{fb_h});
10. error.

This concept of pupil behavior may be explicitly defined in terms of a model taking the form of Equation VI.

Equation VI

$$pb_{h_j} = f \left[\left(\overline{s_{tb_{i_j}}} \right), (pc_{1_h} \dots pc_{n_h}), (s_{pb_{lm_{cc_j}}}), (s_{pb_{lm_{a_j}}}), \right. \\ \left. (s_{pb_{lm_{g_j}}}), (\overline{s_{ad_j}}), (pb_{cg_h}), (s_{cul_j}), (pb_{fb_h}), (e) \right]$$

where:

pb_{h_j} = behavior of pupil h in situation j ;

$\overline{s_{tb_{i_j}}}$ = sum total behavior of teacher i in situation j
 $(s_{tb_{1_{i_j}}} \dots s_{tb_{n_{i_j}}})$;

$pc_{1_h} \dots pc_{n_h}$ = pupil characteristics of pupil h where:

$$pc_{n_h} = f \left[\left(\overline{p_{cn_h}} \right), (p_{ps_{n_h}}), (e) \right]$$

where:

pc_{n_h} represents some specified characteristic n of pupil h ;

$\overline{p_{g_{n_h}}}$ represents the genetic context, or sum total of pupil h's genetic background contributing to characteristic n;

$\overline{p_{ps_{n_h}}}$ represents pupil h's past situational context (sumtotal of pupil h's past situation background, contributing to characteristic n), including previous formal learning and educational experience ($\overline{p_{ps_{ed_h}}}$)¹¹, acquired motivational components ($\overline{p_{ps_{m_h}}}$), home influences ($\overline{p_{ps_{h_h}}}$) peer and cultural influences ($\overline{p_{ps_{cul_h}}}$) contributing to pupil characteristic n.

$s_{pb_{lm_{co_j}}}$ = the sum total of learning materials content (i.e., knowledge, understanding, attitudes, values, skills and processes to be learned--which both reflect and help to define the pupil behavior goal or objective) in situation j.

$s_{pb_{lm_a_j}}$ = sum total of aids to learning (e.g., visual aids, laboratory exercises, auto-instructional devices and programs, etc.), re situation j ($s_{pb_{lm_a_j}} = s_{pb_{lm_{a_1j}}} \dots s_{pb_{lm_{a_nj}}}$).

$s_{pb_{lm_g_j}}$ = sum total of pupil behavior objectives of goals that provide the setting for, and direction in, situation j

¹¹Note that $\overline{p_{ps_{ed_h}}}$ subsumes earlier teacher influences, $\overline{p_{ps_{tb_h}}}$, counseling influences, $\overline{p_{ps_{cg_h}}}$, previous content to which exposed, $\overline{p_{ps_{lm_{co_h}}}}$, etc.

$$(s_{pb_{lm_g}} = s_{pb_{lm_{g_1}}} \dots s_{pb_{lm_{g_n}}}).$$

s_{ad_j} = sum total of applicable administrative policy and practice in situation j. ($s_{ad_j} = s_{ad_{1j}} \dots s_{ad_{nj}}$) where $s_{ad_{nj}}$ represents a specific administrative control, direction, etc., which must be taken into account in situation j.

$s_{pb_{cg_j}}$ = sum total of formal counseling-guidance, relevant to situation j, to which the pupil has been exposed.

s_{cul_j} = sum total of cultural conditions (community, geographic division, peer group, etc.) which bear on situation j ($s_{cul_j} = s_{cul_{1j}} \dots s_{cul_{nj}}$).

pb_{fb_h} = sum total of feedback resulting from behavior of pupil h in previous learning situations having elements in common with situation j.

e = error component.

Equation VII is an extension of Equation VI and represents the more abstract concept, the over-all pupil behavior of pupil h.

Equation VII

$$\overline{Pb}_h = f[(\overline{Tb} \dots \overline{Tb}_{n_h}), (\overline{Pc}_h), (Pb_{lm_{co}}), (Pb_{lm_a}), (Pb_{lm_g}), (\overline{Ad}), (Pb_{cg}), (\overline{Cul}), (Pb_{fb_h}), (e)]$$

where:

$\overline{Pb}_h$ = an abstraction representing the over-all behavior of pupil h in a variety of learning situations;

$\overline{Tb}_1 \dots \overline{Tb}_n$ = sum total teacher behavior of all teachers to whom pupil h is and has been exposed.

Pc_h = sum total of interacting pupil characteristics (abilities, age, sex, etc.) of pupil h.

$Pb_{Lm_{co}}$, Pb_{Lm_a} , Pb_{Lm_g} , $\overline{Ad}$, Pb_{cg} , $\overline{Cul}$ = sum total, respectively, of

learning materials content, learning materials aids, pupil behavior goals (i.e., the school's objectives administrative policies, counseling-guidance and cultural influences to which pupil h is and has been exposed.

Pb_{fb_h} = sum total of feedback re pupil h.

Similarly, Equation VIII relates to the behavior of pupils in general--the abstract concept of the composite behavior of all pupils.

Equation VIII

$$\hat{Pb} = f \left[(\hat{Tb}), (Pc), (Pb_{Lm_{co}}^{\wedge}), (Pb_{Lm_a}^{\wedge}), (Pb_{Lm_g}^{\wedge}), (\hat{Ad}), (Pb_{cg}^{\wedge}), (\hat{Cul}), (\hat{Pb}_{fb}), (e) \right]$$

where:

$\hat{Pb}$ = an abstraction representing pupil behavior in general, i.e., the pupil behavior of all pupils.

$\hat{Tb}$ = the sum total teaching behavior of teachers in general, (i.e., $\overline{Tb}_1 \dots \overline{Tb}_n$).

$\hat{Pc}$ = the sum total pupil characteristics of pupils in general, (i.e., $\overline{Pc}_1 \dots \overline{Pc}_n$)

$Pb_{Lm_{co}}^{\wedge}$, $Pb_{Lm_a}^{\wedge}$, $Pb_{Lm_g}^{\wedge}$, $\hat{Ad}$, $Pb_{cg}^{\wedge}$, $\hat{Cul}$ = sum total, respectively,

of learning materials content, learning aids, pupil behavior goals, administrative policies, counseling-guidance to which pupils have been exposed, and cultural influences of educational programs in general.

$$\hat{Pb}_{fb} = \text{sum total of pupil feedback.}$$

Figure 6 is a schematic representation of the pupil as an information-processing system; it shows the conditions and relationships stated in Equation VI. Figure 5, page 45, also supplements the equations describing pupil behavior and illustrates the interaction of pupil, teacher, and situation in pupil information processing.

APPLICATION OF THE INFORMATION- SYSTEM MODEL TO THE INSTRUCTIONAL PROCESS

The Teacher as an Information- Processing System

Figure 4, on page 43, indicates some of the major components involved in teacher behavior and portrays the teacher as an information-processing system.

At the bottom of the chart are shown certain teacher behavioral capabilities and characteristics which may be considered inputs in teacher information processing. These include both genetic and acquired characteristics which have been grouped under the major categories: physical-physiological characteristics; general capabilities; characteristic abilities-capacities; characteristic teacher behaving styles; characteristic affective sets; and retrievable information. These information inputs and information-processing capabilities are all internal to the teacher and may be thought of as interacting characteristics of the teacher.

The external information inputs that also affect teacher information processing have been listed at the top of the chart. They include the objectives-goals of teaching in a particular situation, the behavior content to be taught, the aids that are available and applicable for facilitating learning of behavior content, the pupil behavior (both of a particular pupil and of the group of pupils comprising a class or subgroup of a class), the relevant administrative policies the counseling-guidance to which pupils have been subjected, and the pupil's culture.

The teacher information processing proper, the middle section of the chart, includes input processing, processing of information preliminary to decision-making and channeling, and the processing of information output for use, i.e., programming of behavior preparatory to information exchange to the pupil system. All of these processes culminate in the information output or the behavior of the instructor in the particular teaching situation.

At the extreme right of the chart the pupil is indicated as the destination/receiver of the information transmitted by the teacher.

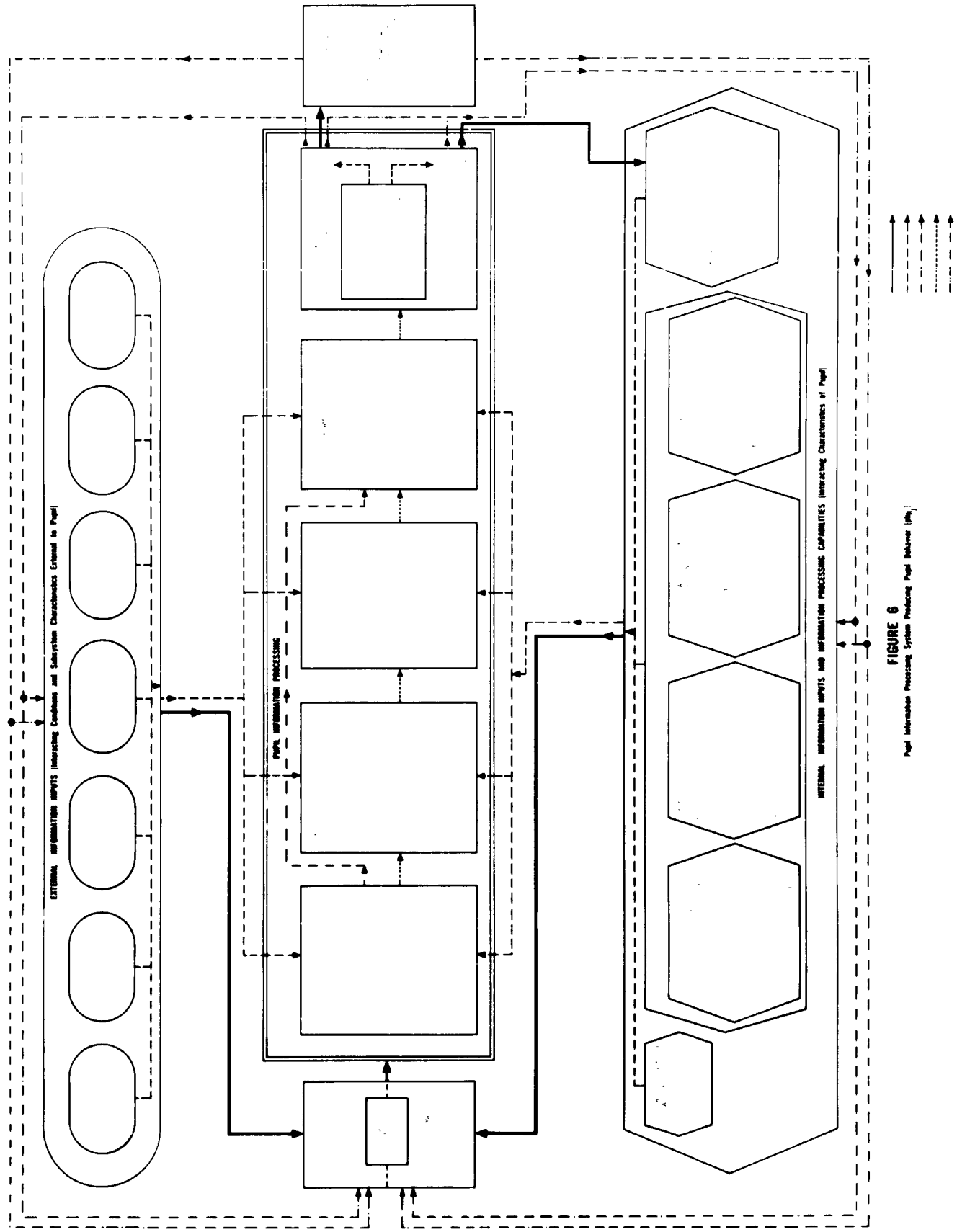


FIGURE 6
Pupil Information Processing System Producing Pupil Behavior (Pb)

In addition to the direct transducer output-inputs noted in Figure 4 the important interactions among inputs, including the operation of feedback inputs, and their influence on different phases of teacher information processing are made explicit by the diagram.

The Pupil as an Information-Processing System

Figure 6 bears certain similarities to Figure 4. It represents the hypothetical pupil information-processing system resulting in pupil behavior. Again, the internal information inputs and information-processing capabilities (or interacting characteristics of the pupil) are noted at the bottom of the chart, and the external information inputs are shown at the top. The middle section of the chart indicates the pupil information processing resulting in pupil behavior and the effect of that behavior, delayed or immediate, upon the physical or social environment of the pupil.

Instruction Involves Interaction of Teacher, Pupil, and Situation

The "dyadic" sequence referred to by Sears and adopted by the writer in early statements of theory about teacher behavior takes into account the fact that teacher, pupil, and situation cannot be considered independent of one another. Figure 5 shows the interaction between the teacher system, the pupil system, and the situation complex. There are direct lines of communication (transducer outputs-inputs) between the three. There also is feedback from the product of the information-behavior output (effect of the pupil behavior on the physical or social environment) that affect teacher and pupil, and often the situation.

In this chart the hierarchical nature of teacher behavior and pupil behavior is suggested. Genetic characteristics or traits of the teacher, for example, (t_g) and the past situational conditions which have affected the teacher (t_{ps}) result in the development of teacher characteristics. These teacher characteristics in turn form teacher behavior patterns such as the warm-friendly, systematic-responsible, stimulating-imaginative, and other patterns. And these patterns in turn contribute to the major constructs describing teacher behavior, namely: motivating, presenting, organizing, evaluating, and counseling-advising.

The Situation as a Mediator in the Expression of Teacher Behavior

Figure 7 shows that the characteristics and capabilities of the teacher must conform to and may be altered by the operating conditions of the teaching situation. This schematic representation of a hypothetical hierarchical system of teacher characteristics-behavior also shows how the major classes of teacher behavior may result, and how either singly or in combination, they may contribute to behavior of a particular teacher in a particular teaching situation.

Integration of Instruction
and the Role of the Teacher

Teachers, or teachers plus textbooks, no longer are the only components in the instructional process. Certainly this is the case insofar as the presenting of information is concerned. Indeed, it may be that the teacher of the future will become less of an information presenter and more of an organizer of the instructional process. Such a possibility is intriguing, and it can easily be fit into the information system theory of instruction. In the future, much heavier demands may be placed upon those persons in our culture traditionally known as teachers or instructors as they become selectors, programmers, and controllers both of the information to be communicated and of the channels (i.e., media) of communication. Increased emphasis in teacher education and in classroom and/or individual learning situations undoubtedly will be placed upon the teacher as an integrator and organizer of all the functions described as "teacher behaviors" (i.e., motivating, presenting, organizing, evaluating, and counseling) whether those functions really are performed by a teacher or some other medium or set of media in an optimally organized sequence.

Figure 8 represents an application of the integrated instruction concept in an information system context and is suggestive of the role of the teacher as the integrator.

HEURISTIC VALUE OF INFORMATION SYSTEM
THEORY FOR TEACHER BEHAVIOR RESEARCH

There are several advantages of a theoretical model for the teacher educator, the researcher in education, and the practitioner. A theoretical framework serves such purposes, or has such advantages as: making explicit the variables and conditions involved in teaching-learning and providing a summary of those variables, showing how the available information is organized; aiding definition and description of teacher behavior; providing an important selective and directing function to researchers, permitting research to proceed systematically, bringing new relationships to light and suggesting analogies; making explicit the gaps in knowledge that otherwise might go unnoticed; and, in general, serving a heuristic purpose, leading to the generation of hypotheses to be researched.

It is this last feature that makes theory of particular interest and concern to the educational researcher--its deductive fertility. It is hoped that the sort of a theoretical model presented here may suggest problems for investigation.

It also suggests that education as a whole is essentially an information-providing system, some of that information consisting of the provision of rules and concepts which permit the learner to proceed more effectively with the learning process itself. It is believed that such a theory can be of significant and direct service to teacher educators and teacher education institutions as well as to researchers.

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Major Classes of Teacher
[Teaching] Behavior

Operating Conditions and
Situational Characteristics

Teacher Capabilities and
Characteristics

1

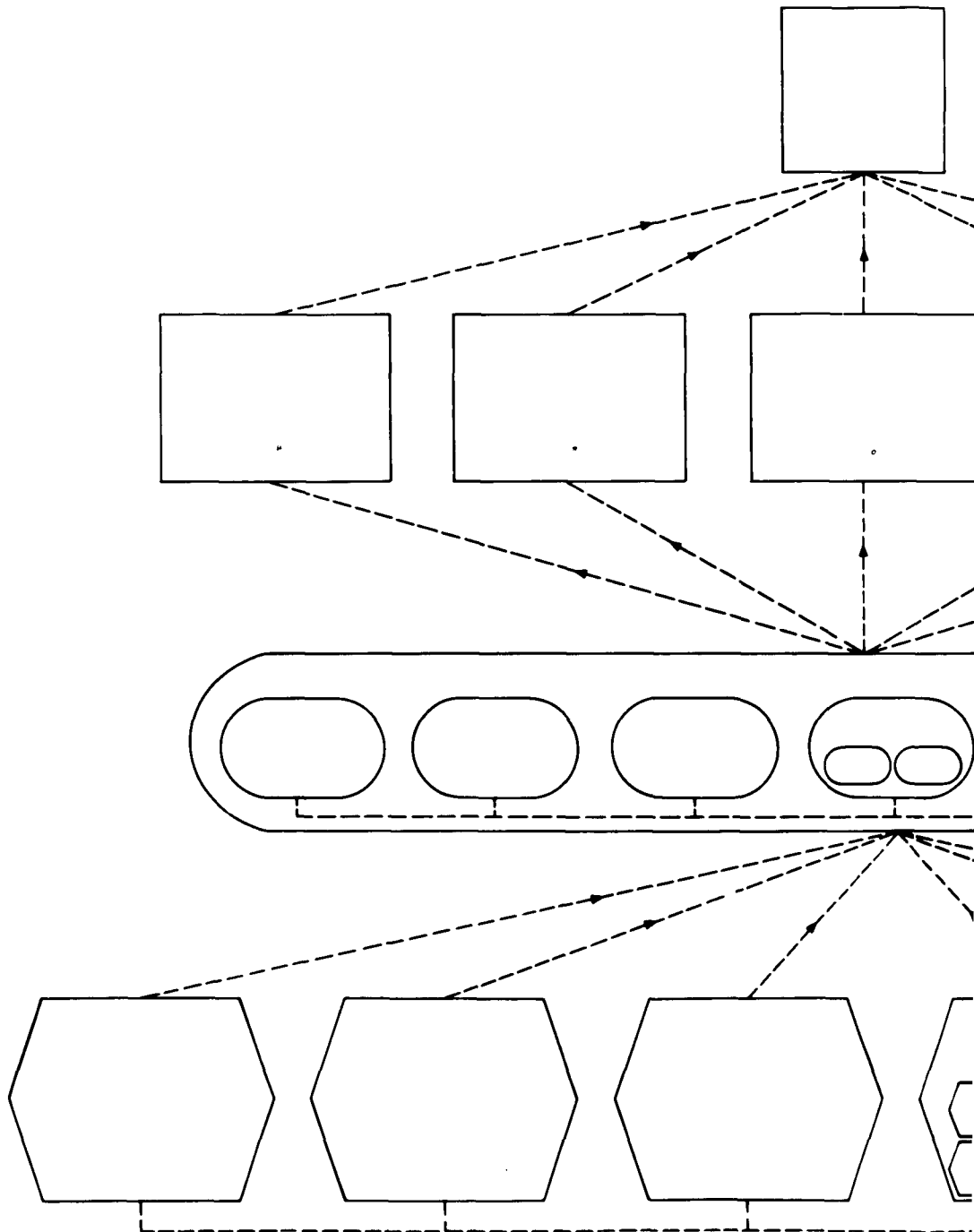


FIGURE 7

Schematic Representation of an Hierarchical System of Teacher Characteristics I

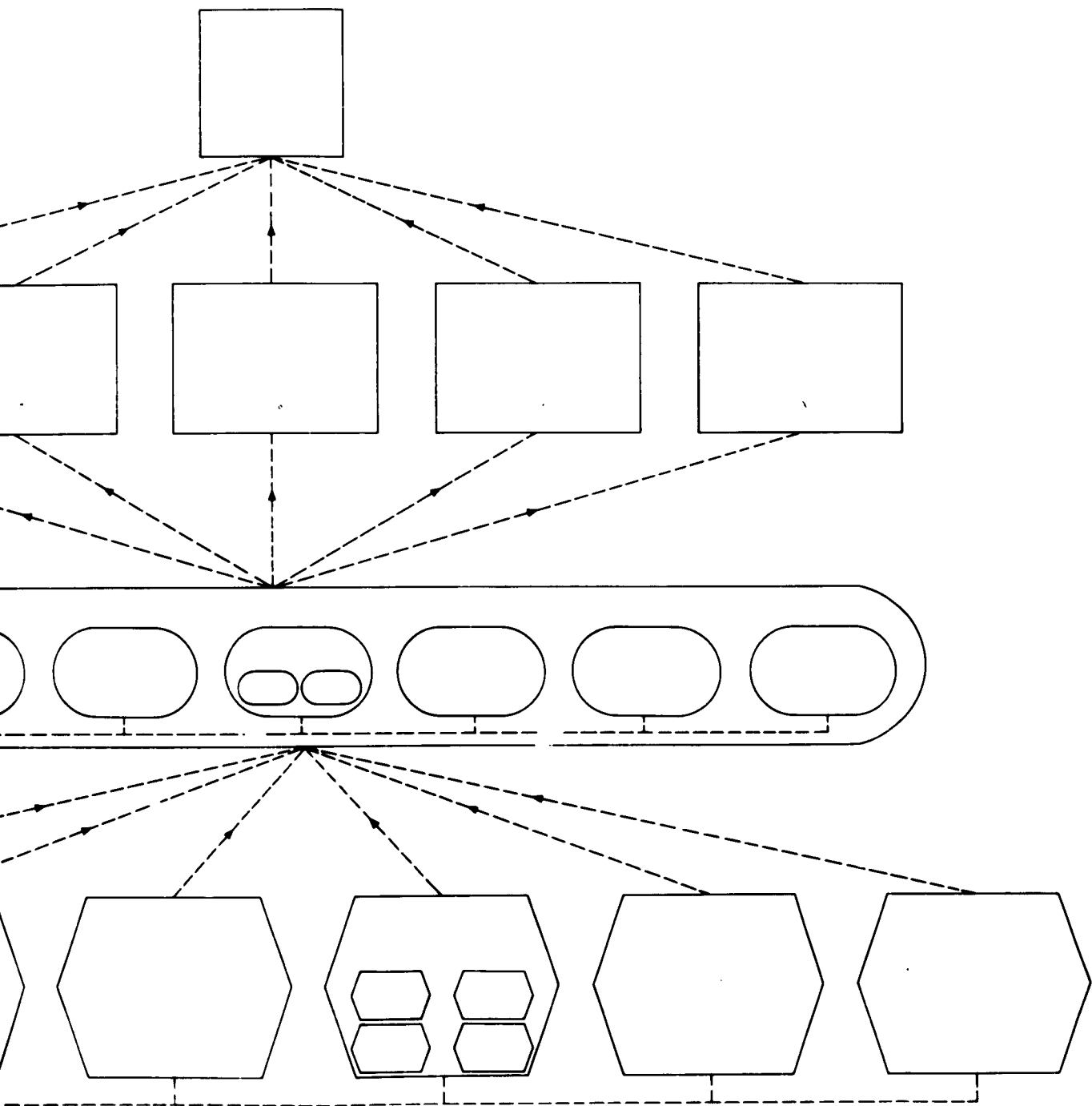


FIGURE 7

Symbolic Representation of an Hierarchical System of Teacher Characteristics-Behavior and Mediating Situational Conditions

Learning content	General student behavior domain*	General kind of information transmission	Teacher behavior	Mediating conditions		Learning Aids**	
				Internal to Student (General capabilities: characteristic abilities, capacities, behavior styles, affective state, and previously acquired behavior or "retrievable information")	External to Student (Availability of films or group, social facilities, cultural setting, administrative policy, guidance program)		
Writing skill x (or, science, foreign language, history, etc.)	Acquisition of facts, principles, understandings, skills, "sets," behavior styles, etc.; for - direct use - analogizing or transfer - mapping for "discovery" - recombining-reorganizing	Facts, concepts, and rules in the cognitive-behavioral domain	Motivating (M) Presenting (P) Organizing (O) Evaluating (E) Counseling (C)	" " " " "	Varying for group " " " "	TV, EDI, AI, F, D, B, C, M, T*** TV, AI, F, D, B, C, M, T AI, EDI, T (others?) T, EDI, AI (others?) T, EDI (others?)	Receiving, responding, accepting Receiving actively and integrating "associates" Receiving, responding, renewing, utilizing some topics, etc. Receiving, adapting, counseling
Social attitude x (or "scientific attitude," autonomous motivation, emotional adjustment, aspiration level, orientation toward particular values, etc.)	Acquisition of facts, principles, understandings, skills, "sets," behavior styles, etc.; for - direct use - analogizing or transfer - mapping for "discovery" - recombining-reorganizing	Facts, concepts, and rules in the affective-behavioral domain	Motivating (M) Presenting (P) Organizing (O) Evaluating (E) Counseling (C)	" " " " "	" " " " "	AI, TV, F, D, B, T (others?) AI, TV, F, D, B, T (others?) T (others?) AI, EDI (others?) T (others?)	Receiving Receiving Receiving Receiving
Writing skill x (or musical skills, drawing skills, dancing, particular vocational skills, particular athletic skills)	Acquisition of skills, behavior styles, etc.; for - direct use - analogizing or transfer - mapping for "discovery" - recombining-reorganizing in "creative" activity	Facts, concepts, and rules in the psychomotor-behavioral domain	Motivating (M) Presenting (P) Organizing (O) Evaluating (E) Counseling (C)	" " " " "	" " " " "	TV, AI, F, D, B, C, M, T (others?) TV, AI, F, D, B, C, M, T (others?) T (others?) F, T, AI (others?) F, T, EDI (others?)	Receiving, responding, accepting Receiving, responding, organizing skills in Receiving, performing, applying, learning, remedial Receiving, adapting, counseling

FIGURE 8.

INTEGRATED SYSTEMS APPROACH TO INSTRUCTION AND SOME ELEMENTS INVOLVED

*The objectives noted are "general" in nature. Specific objectives or goals must be spelled-out operationally (in terms of expected student behaviors) with regard to (a) each topic and subtopic of each learning content field, (b) the student behavior domain involved, (c) the general form of information to be transmitted to the student, and (d) the behavior engaged-in by the student (upon receipt of the information transmitted) in integrating it into his behavior hierarchy.

**The planning, organization, and coordination of learning aids is a teacher responsibility.

The following code with respect to learning aids is employed: educational television (TV); educational data processing (EDP); automated instruction and programmed learning (AI); films (F); demonstrations (D); text and reference books (B); charts and maps (C); physical or abstract models (M); and tests and examinations (T).

***The statement of these learning aids as "applicable" in the described situation is purely hypothetical; the extent to which any, or several aids in some integrated combination, may actually aid information transmittal to the student must be studied experimentally.

Mollating Conditions

General conditions

(behavior of student or group, sex, facilities, cultural setting, individual differences, policy, etc.)

Program	Learning Aids	Student Learning Behavior
Varying for group	TV, EP, AI, F, P, D, T, I	Receiving intended information and actively responding by establishing "set" or readiness, curiosity, anxiety; receiving and accepting reinforcement
"	TV, AI, F, P, D, T, I	Receiving information to be acquired and actively responding by repeating, organizing and integrating into association map or "association hierarchy" of behavior
"	AI, EP, T (others?)	
"	F, P, D, AI (others?)	Receiving information (feedback) and actively responding by appropriately adapting (i.e., renewing learning activity, applying available remedial procedures, going on to next topic, etc.)
"	I, EP (others?)	Receiving information and adapting, or not adapting, behavior in accordance with controlling guidance
"	AI, TV, F, P, D, T (others?)	Receiving intended information...
"	AI, TV, F, P, D, T (others?)	Receiving information to be acquired...
"	I (others?)	
"	AI, EP, D (others?)	Receiving information (feedback)...
"	I (others?)	Receiving information and adapting...
"	TV, AI, F, P, D, T, I (others?)	Receiving intended information and actively responding by establishing set or readiness for program; receiving and accepting reinforcement
"	TV, AI, F, P, D, T, I (others?)	Receiving information to be acquired and actively responding by imitating, repeating, organizing and integrating into behavioral skills hierarchy
"	I (others?)	
"	F, P, D, AI (others?)	Receiving information (feedback) regarding performance and actively responding by appropriately adapting (i.e., renewing learning activity, applying available remedial procedures, etc.)
"	F, P, D, I (others?)	Receiving information and adapting or not adapting behavior in accordance with controlling guidance

FUNCTION AND ROLE OF LEARNING INVOLVED



The theory presented here is very broad, and can therefore subsume most other conceptualizations about teaching--e.g., role theory, personal interaction theory, equilibrium theory, teaching as problem-solving, teaching as a logical process, etc. At the same time, an information system theory of instruction is representative of a unique point of view and in one sense might be thought of as a metatheory which simultaneously gets at the heart of the teaching-learning process in concentrating on the teacher and the pupil as information-processing systems and, at the same time, accounts for the phenomena, the postulates, and the theorems that make up the subtheories describing the various facets of teaching.

The problem that must next be faced is how to cut the complex picture of instruction down to size so as to actually research it, and understand and explain it, how to determine the appropriate subsystems, how to measure the transmission and the receipt-storage-retrieval of complex information such as that involved in formal education, and how to conduct research to discover whether or not aspects of the general theory of information systems hold up.

Probably this must be accomplished, as it is in the researching of any major complex problem, by moving down the ladder, so to speak, and first studying sub-subsystems. We first must attack the smaller problems involving smaller numbers of interactions and elements. Then by thus limiting the conditions we see if we can come up with some bite-sized models. If these smaller models do indeed fit empirical results, they may, in turn, be merged and the pieces fitted together into larger patterns. And, thus, eventually, we may be able to integrate the findings and determine how they fit the still larger and more all-embracing molar model.

A number of suggestions are accumulating in the literature. Leads and cues regarding measurement should come from extension of the methods of content analysis (2, 3, 27, 28), from techniques such as those employed by Bloom (7) for the study of thought processes, from classroom feedback investigations (e.g., Gage, et al, 14), from linguistics research (18, 25) from, of course, information and communication theory (10, 11, 12, 19, 22, 23, 38, 39), from the study of human perception-communication represented in the research and speculations of Broadbent (8) and others, from semantics thinking (10, 26, 27, 29), and from sociology and psychology in general.

It is reasonable to assume that research evidence on visual and auditory pattern recognition, human information retrieval, on decision-making processes, on human responsiveness to various educational media, and on a variety of other problems related to communication and learning will provide building blocks for the understanding of an information systems theory of instruction such as that proposed in this paper.

NOTE: Since the preparation of this paper the Handbook of Research on Teaching (13) has been published. Chapter 3 is entitled, "Paradigms for Research on

on Teaching." In this chapter, Gage reviews various approaches to theory that have influenced research on teaching and related fields, comments upon them, and considers the possibility of a unified theory of instruction.

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AN INFORMATION-SYSTEM APPROACH TO THEORY
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43 refs., 8 figs.

Unclassified report

DESCRIPTORS: Instructors. Students.
Education.

Reports that the Teacher Characteristics
Study was an eight-year research effort,
consisting of over one-hundred sub-
investigations, which was directed at

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a) the determination of major teacher
behavior patterns observable in the
classroom, b) the development of
inventory estimates of certain teacher
characteristics, c) study of background and
environmental variables related to teacher
behavior, and d) study of relationships
between teacher characteristics and observed
pupil behaviors. Also reports that the design
dictated "going into the classroom" and employing
trained observers to systematically observe and
record what transpired when teachers and pupils
reacted and interacted in the learning environment.
Lists the influencing conditions that have led
to this "information system theory of
instruction".

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