Classes of Instructional Variables

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In this article, we describe the classes of variables which we believe must be considered when one is designing instructional materials, doing research on instructional variables, or developing better methods of instruction. Familiarity with these classes of variables can help instructional designers by indicating what sorts of method variables should be included in their designs and what sorts of conditions may influence how and when those method variables should be used. It can also help instructional scientists, such as researchers and theory builders, by indicating important relationships for investigation or theory building and by providing a common terminology for discussing such relationships.

There is a growing interest in the *design science of instruction* (Glaser, 1976; Reigeluth, Bunderson, and Merrill, 1978). The major products of this design science are prescriptive principles of instruction, which provide an increasingly powerful *knowledge base* for the professions of instructional design and evaluation (Reigeluth and Merrill, 1978). When a sufficient number of these principles is discovered, they should allow instructional designers to prescribe instructional methods that are more likely to be optimal for given sets of conditions, and they should help instructional evaluators identify (without expensive empirical trials) methods that are not optimal for given sets of conditions.

In essence, prescriptive principles of instruction describe *cause-and-effect relationships* among instructional variables. Before principles and theories (which are interrelated sets of principles) of instruction can be developed, the instructional variables that they include must be clearly described and unambiguously labeled. In recognition of this need, Reigeluth, Bunderson, and Merrill (1978) advocated the use of "top-down," deductive theory-construction procedure (see Snelbecker, 1974).

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This theory-construction procedure entails four stages: (1) what Snow (1973) refers to as "D-Theory" (descriptive theory and taxonomy) construction, which is the identification, description, and classification of instructional *variables,* both on the "cause" side (i.e., the independent variables), and on the "effect" side (i.e., the dependent variables); (2)the formulation of some basic postulates (i.e., hypothesized *principles*) which relate those independent and dependent variables to each other through the specification of certain methods or strategies under certain conditions; (3) the use of those postulates to derive testable deductions, predictions, or hypotheses and to test the validity of each postulate by systematic *experimental testing* of the hypotheses; and (4) the creation and testing of optimal *models* of instruction, which are combinations of method variables (see Reigeluth, 1978, for a discussion of model creation and testing).

Instructional scientists are interested in prescribing *methods* of instruction that are highly effective under given *conditions.* But the way we conceptualize and categorize those conditions and methods can have a large impact on the stability and usefulness of the relationships that are identified between those conditions and methods. Therefore, a matter of great importance is the manner in which we define and classify all the methods and conditions that we wish to investigate; and the ultimate value of any classification scheme that we adopt is determined by the stability, magnitude, and importance (meaningfulness) of the cause-and-effect relationships that are found to exist among those categories.

There are two factors that can influence the stability and magnitude of those cause-and-effect relationships: (1) the preciseness of definition of the categories, and (2) the nature of the categories. The *nature of the categories* is determined by the way in which referents (objects, symbols, and events) are classified. For instance, trees may be classified according to their age (e.g., seedling, sapling), their kind of leaf (e.g., pine, deciduous), or their genus (e.g., oak, maple). The instructional world can also be "sliced" in different ways. Practically all classification schemes improve our understanding of the objects, symbols, or events being categorized; but some of them will have high predictive value, while others will have virtually no value for predicting the outcomes of instruction.

With respect to the *preciseness of definition,* many categories of methods that are frequently used in research and theory construction are not very useful because the stability of their cause-and-effect relationships is jeopardized by the looseness or the high level of generality of their definition. For instance, "lecture" vs. "discussion group," "inductive" vs. "deductive," and "discovery" vs. "reception" may often vary more within each category than between categories. In such cases, it is necessary to break down these "methods" into their building blocks, and to base one's research and theories on those more precise and clearly defined *strategy components.*

In spite of concerted efforts by many instructional scientists, the lack of a comprehensive set of clearly defined variables and the lack of a common terminology are among the greatest impediments to progress in instructional science. This article is not intended to present a comprehensive taxonomy of instructional variables, although the authors are currently working toward that goal. Rather it takes a preliminary step in that direction by presenting (1) a scheme for classifying instructional variables, and (2) a model which hypothesizes the most important interrelationships among those classes.

Categories of Variables

The authors propose that it is helpful to classify all the variables that are of interest to instructional scientists as belonging to three categories: conditions, methods, and outcomes. Because of our "prescriptive science" orientation (i.e., providing prescriptions that are useful to instructional designers and evaluators), the only *conditions* that interest us are those which both (a) interact with methods, and (b) cannot be manipulated by the instructional designer or educator. Conditions which do interact with methods but can be manipulated become, in effect, methods for improving instructional outcomes; and conditions that do not interact with methods have no value for deciding when to use which methods.

The second category, instructional *methods,* includes all the different ways to achieve different outcomes under different conditions. By definition, all methods can be manipulated by the instructional designer or educator. If a "method" cannot be manipulated in a given situation, then it has become a condition. Therefore, conditions and methods are not fixed categories—they may vary from one setting to another. For instance, in school *A* it may be possible to use a variety of parameters of a method variable, whereas in school *B,* it may be possible to use only one of those parameters. In such a case, that which is a method variable in school *A* is a condition in school *B* (assuming that it interacts with method variables in school *B*).

The third category, instructional *outcomes,* includes all the various effects that provide a measure of the value of alternative methods of instruction under different conditions. Therefore, outcomes include effects on such people as teachers, maintenance personnel, and parents, as well as effects on the students.

There are two sets of important interrelationships among the conditions, the methods, and the outcomes of instruction (see Figure 1). For *descriptive scientists* (i.e., learning theorists and researchers), the conditions and the methods are independent variables; and their parameters conditionally interact to produce a set of outcomes, which are the dependent variables. On the other hand, *prescriptive scientists* (i.e., instructional theorists and researchers, instructional designers, and evaluators) use the descriptive scientists' knowledge about the relationships among variables to prescribe methods of instruction. The conditions and the outcomes are the independent variables; and their parameters (in interaction) are used to prescribe the parameters of the method variables, which are the dependent variables.

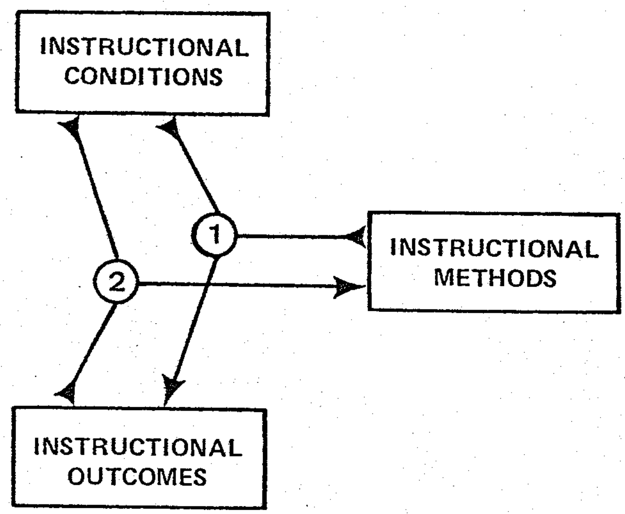
In the remainder of this article, we break down each of these three categories into *classes of variables;* we describe each class, and we indicate the major interrelationships among those classes. Since the method variables are of central importance to both descriptive and prescriptive scientists, we discuss them first.

METHODS

Keeping in mind the two sets of relationships shown in Figure 1, it will now be helpful to simplify this representation for further elaboration. Figure 2 shows the three categories of instructional variables, and it shows that conditions have the major (but by no means only) effect on the selection of methods and that methods have the major (but by no means only) effect on outcomes.

Like trees (see above), instructional methods can be classified in a variety of different ways. As opposed to classifying them along such lines as methods for teaching mathematics, reading, etc., or special education, adult education, etc., we propose that the following classification will have high prescriptive utility. *Instructional method variables* can be conceptualized as being of three kinds: components of strategies for organizing instruction, components of strategies for delivering the instruction to the learner, and components of strategies for managing the interaction of the learner with the instruction (see Figure 2).

- *Organizational Strategy Variables*: Components of methods for organizing the subject-matter content that has been selected for instruction. "Organize" refers to such things as choice of words, diagrams, for-



1. For an instructional researcher the condition variables and the method variables are independent variables; and their parameters may interact to produce fairly consistent effects on the outcome variables, which are dependent variables.

2. For an instructional designer (e.g., a professor or textbook writer) the desired outcomes and the conditions are independent variables which may also interact; and their parameters are used to prescribe good methods of instruction which are the dependent variables.

Figure 1. Three categories of instructional variables, and two sets of interrelationships among those categories.

mat, and student response possibilities. (See below for more detail.)

- *Delivery Strategy Variables*: Components of methods for conveying the instruction to the learner and/or for receiving and responding to input from the learner. (See below for more detail.)
- *Management Strategy Variables*: Components of methods for arranging the interaction between the learner and the other method variables—the organizational and delivery strategy variables. See details below.

Organizational Strategy Variables

Organizational strategy variables can be divided into two important kinds: presentation strategy variables, and structural strategy variables.

- *Presentation Strategy Variables*: Components of methods for organizing the instruction on a *single* construct (i.e., a single concept, procedure, principle, etc.).
- *Structural Strategy Variables*: Components of methods for organizing those aspects of instruction which relate to more than one construct.

Presentation Strategy Variables. The most generic presentation strategy variables have been labeled by Merrill (Merrill, Reigeluth, and Faust, in press; Merrill, Richards, Schmidt, and Wood, 1977; Merrill and Wood, 1974) as "primary presentation forms," and they include the following: (1) *generalities,* such as definitions of concepts and statements of procedures and principles; (2) *instances,* such as examples of a concept, applications of a procedure, and explanations of a principle; (3) *generality practice,* which is student recall or recognition of a generality; and (4) *instance practice,* which requires the student either (a) to remember an instance or (b) to work an instance, such as classifying an instance as to whether or not it is an example of a concept, performing an instance of a procedure, or explaining an instance of a principle.

Each of these four types of variables can in turn be analyzed as to its characteristics, such as formatting and construction (Faust, O'Neal, and

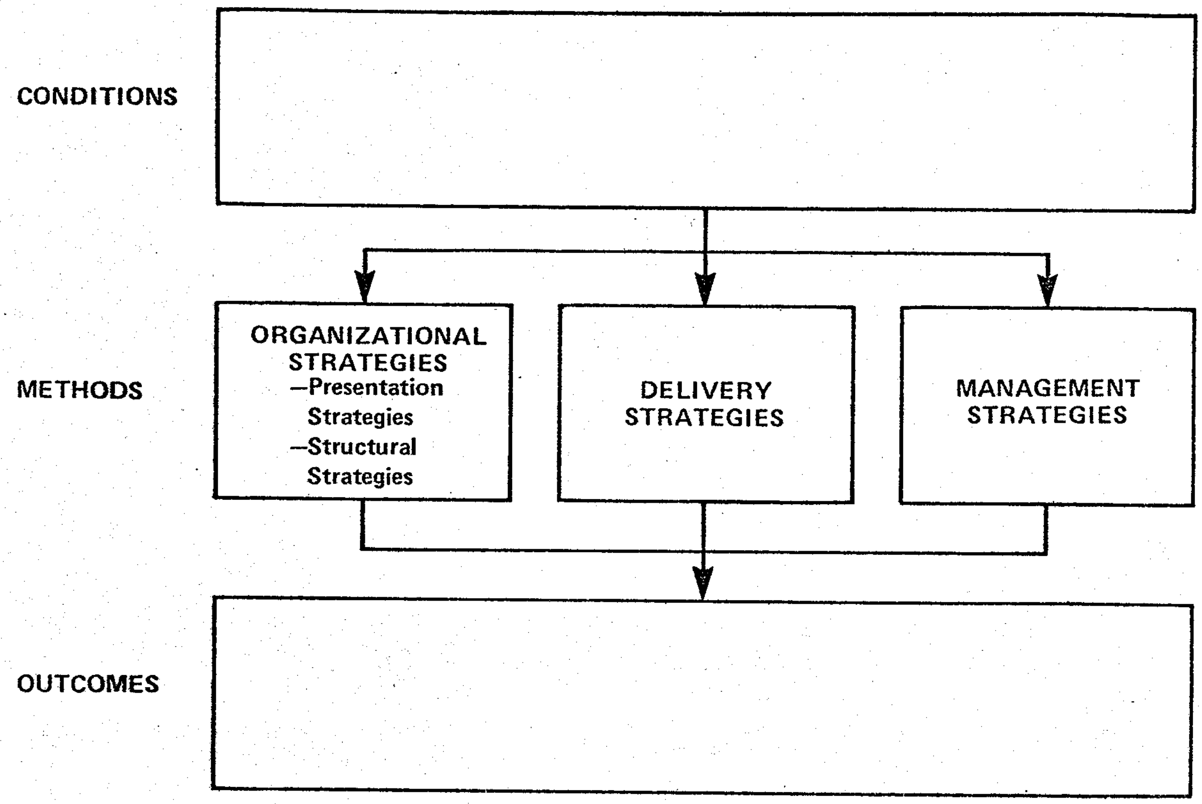


Figure 2. A model showing the major categories of instructional variables and a simplification of the relationships among those shown in Figure 1. Method variables are broken into three major classes.

O'Neal, in press). Each can also be analyzed as to its strategy components, such as the presence of *feedback* after practice, an adequate *sampling* of instances with respect to number, divergence, and difficulty level of instances, and the use of mathemagenic information (i.e., instructional "helps"), which includes attribute isolation and such "secondary presentation forms" as mnemonics, algorithms, or heuristics, and alternative representations (Merrill, Reigeluth, and Faust, in press). These strategy variables all deal with how to internally organize the instruction on each construct.

Structural Strategy Variables. Structural strategy variables deal with how to select, sequence, synthesize, and summarize a number of related constructs (i.e., concepts, procedures, etc.). *Selection* at this level (i.e., given certain goals) refers to decisions as to which constructs and relations among those constructs are needed to accomplish the goals. *Sequencing* refers to decisions as to the order(s) in which those constructs and relations should be presented in the instruction. *Synthesizing* refers to decisions as to how to show the important relations among those constructs. And *summarizing* refers to decisions as to how to preview or review the constructs and relations taught. These are all "multi-construct" strategy questions. (For an in-depth treatment of structural strategies, see Reigeluth, Merrill, and Bunderson, 1978; and Reigeluth *et al.*, 1978).

Delivery Strategy Variables

Delivery strategy variables are components of methods for carrying out the instructional process. There are at least two important functions of delivery strategies (see Merrill and Goodman, 1972): (1) conveying information to the student, and (2) providing for student performances (i.e., practice and tests). Although there are some important differences in delivery strategy needs for these two functions, the strategy variables are mostly the same for both.

There are at least five ways that media may be usefully classified for prescribing delivery strategies: (1) their degree of fidelity of representation,

(2) the degree to which they are interactive (i.e., they provide immediate, individualized responses to student behavior, (3) the degree to which they have useful special capabilities, (4) the degree to which they are motivational, and (5) their costs.

The degree of *fidelity of representation* of a delivery strategy variable usually falls on a continuum, such as the following: objects, sound films, silent films, still pictures, diagrams, audio media, and written symbols. However, this continuum is subject to variation. For instance, instruction on a concert will have a very different continuum of media based on fidelity of representation.

The degree of *interactiveness* of a delivery strategy variable also falls on a continuum, but points on this continuum are indicated by slightly different delivery strategy variables: computers, tutors, workbooks, textbooks/recordings, and broadcasts. Many of these variables can present a variety of the variables discussed in the previous paragraph. For instance, tutors can present all of those variables, and workbooks can present still pictures, diagrams, and written symbols. It is also possible to use a combination of variables, such as (1) a workbook with a film or with objects (e.g., a chemistry lab book), (2) a workbook with a textbook or a broadcast, and (3) written symbols with a film or with objects.

The degree to which a medium provides other *special capabilities* which result in more effective and/or efficient instruction is a third important aspect for prescribing delivery strategies. Those other special capabilities might include simulation (such as a flight simulator that allows a pilot to "land" an airplane ten times in an hour without having to take off again each time to get into position for the next landing), time-lapse features, and other capabilities which give an advantage to a medium that is at a lower level of fidelity of representation.

The degree of the *motivational effect* of a medium is a fourth important aspect for prescribing delivery strategies, but here the variance within categories can often vary as much as, or more than, that between categories. For instance, a tutor can highly motivate a student or he/she can completely turn the student off to the subject matter. These differences are the result of the kinds of management variables and organizational variables used by the medium. This is not to deny that different media have different motivational effects, if all else is held constant. It is also likely that media interact with types of subject matter in their motivational effects.

Finally, the *cost* of a medium is also important for prescribing delivery strategies. Costs for preparing, delivering, and updating instruction can be estimated for each type of medium; and potential costs related to accidents, such as injuries, deaths, and loss of equipment, must also be considered.

Management Strategy Variables

Management strategy variables (Tosti and Harmon, 1973) are components of methods for arranging the interaction of the student with the other instructional method variables—the organizational and delivery variables. From our perspective, it appears that there are at least three important classes of management strategy variables: scheduling, recordkeeping, and motivation variables.

With respect to *scheduling variables*, both delivery strategy components and organizational strategy components may be scheduled. The *scheduling of delivery strategy components* (media) usually involves decisions as to when and for how long a student will use each of a variety of media, such as when the language lab will be most helpful in relation to studying a certain lesson in the Spanish textbook, or when actually flying the airplane will be most helpful in relation to "flying" a simulator, and when the simulator will be most helpful in relation to using a workbook.

The *scheduling of organizational strategy components* usually entails questions as to when and for how long a student should see each organizational strategy component. These questions include decisions as to the optimal order of presentation forms (e.g., is instance-generality-practice better than generality-instance-practice?), the optimal number of instances or practice items, how often past learning should be reviewed, when the test should be given, and even whether or not to study a given strategy component, to cite just a few. Such aspects of the instruction may be *fixed* (i.e., standardized) or *variable* (i.e., individualized) for each student. And if they are variable, they may be *system-controlled*, such as Atkinson's optimal control theory (Atkinson, 1972), or they may be *learner-controlled*, such as on the TICCIT* system (Bunderson, 1974; Merrill, 1975; Merrill, Fletcher, and Schneider, in press). Research indicates that learner control may be incompatible with an educational system based on external accountability (Axtell and Merrill, 1978). This kind of management strategy may specify skipping certain organizational or delivery strategy components.

Recordkeeping variables can have an effect on instructional outcomes to the extent that they

*The TICCIT system is a computer-assisted instruction system developed by Mitre Corporation and Brigham Young University.

provide a basis for *other management decisions.* Both system-controlled scheduling and learner-controlled scheduling require information for the system or the learner to make good decisions, and the need for more motivational strategy components is also indicated by records on a student's performance. A second major application is that *system improvement* depends on information about student performance on different objectives. Such information is important for identifying and correcting weaknesses in organizational, delivery, and management strategies.

Motivation variables are also a very important part of managing the interaction of the student with the instruction. These variables could be classified as two types: those which are *extrinsic* to the learning task (i.e., contingency management), and those which are *intrinsic* (e.g., enjoyment of learning or the importance and usefulness of what was learned). The contingency management technique of positive reinforcement has been shown to have a very beneficial effect on certain kinds of instructional outcomes (Harrison, 1975); but like all extrinsic motivators it ceases when the instruction ceases.

Most subject matter is intrinsically motivational, but most instruction fails to convey its intrinsic appeal. There are components of instruction—motivational variables—that can be used to increase intrinsic motivation to learn a subject matter. Using *good organizational and delivery strategies* so that the instruction is as effective and efficient as possible has an important influence on a student's motivation. In particular, the elaboration model for sequencing and synthesizing instruction (Reigeluth *et al.*, 1978) shows special promise for increasing intrinsic motivation because it places all learning in meaningful contexts, and it emphasizes important interrelationships. But motivational strategies can include much more. McConnell (1978) has indicated how analogies, anecdotes, and hypothetical situations can be used to create more emotional involvement and to show the importance and usefulness of what is being learned by indicating some of its applications.

CONDITIONS

Having just elaborated on instructional method variables (see Figure 3), it is logical to attempt to describe and classify the condition variables which influence the use of those method variables. To be of interest to us for prescribing instructional methods, the condition variables must both (a) interact with methods and (b) be beyond the control of the instructional designer or educator. Our purpose is to identify those condition variables that have important influences on each of the three classes of method variables, and therefore we need to divide the condition variables into three groups.

We hypothesize that goals and subject-matter characteristics have the majority of the influence on the selection (and outcomes) of organizational strategies, that constraints and subject-matter variables have the majority of the influence on delivery strategies, and that student characteristics have the majority of the influence on the selection (and outcomes) of management strategies. However, it is likely that other kinds of condition variables influence each class of variables to some extent (e.g., student characteristics may influence the selection and outcomes of organizational and delivery strategies to some extent).

- *Instructional Goals*: Statements about what the results of the instruction should be. They may be very general, very detailed, or anywhere in between.
- *Subject-Matter Characteristics*: Aspects of a subject-matter area which provide a useful basis for prescribing instructional strategies.
- *Constraints*: Limitations of resources, such as time, equipment, personnel, and money.
- *Student Characteristics*: Qualities or aspects of an individual student, such as student aptitudes, motivation, and prior achievement.

Goals and Subject-Matter Characteristics

Since the classification of subject-matter characteristics will facilitate our discussion of goals, we shall discuss subject-matter characteristics first. But before we proceed with a top-down classification of subject-matter variables, it will be helpful to introduce some fundamental concepts about subject matter.

All subject matter has its origins in referents. *A REFERENT is an object, event, or symbol which exists in our real or imagined environment.* For convenience, referents are grouped together into concepts. *A CONCEPT is a set of referents which are grouped together on the basis of one or more common characteristics,* which are referred to as "critical attributes." As referents are the atomic particles of subject matter, so concepts are the elements with which all subject matter is constructed; and subject matter does not exist except as we create it from referents and concepts.

All subject-matter components can be conceptualized as having three parts: a domain, an operation, and a range (Merrill, 1973; Merrill and Wood, 1974, 1975; Reigeluth, Merrill, and Bunderson, 1978; Scandura, 1968, 1970). *A DOMAIN is comprised of one or more referents of one or more concepts,* which are referred to as "domain concepts." *A RANGE is also comprised of one or*

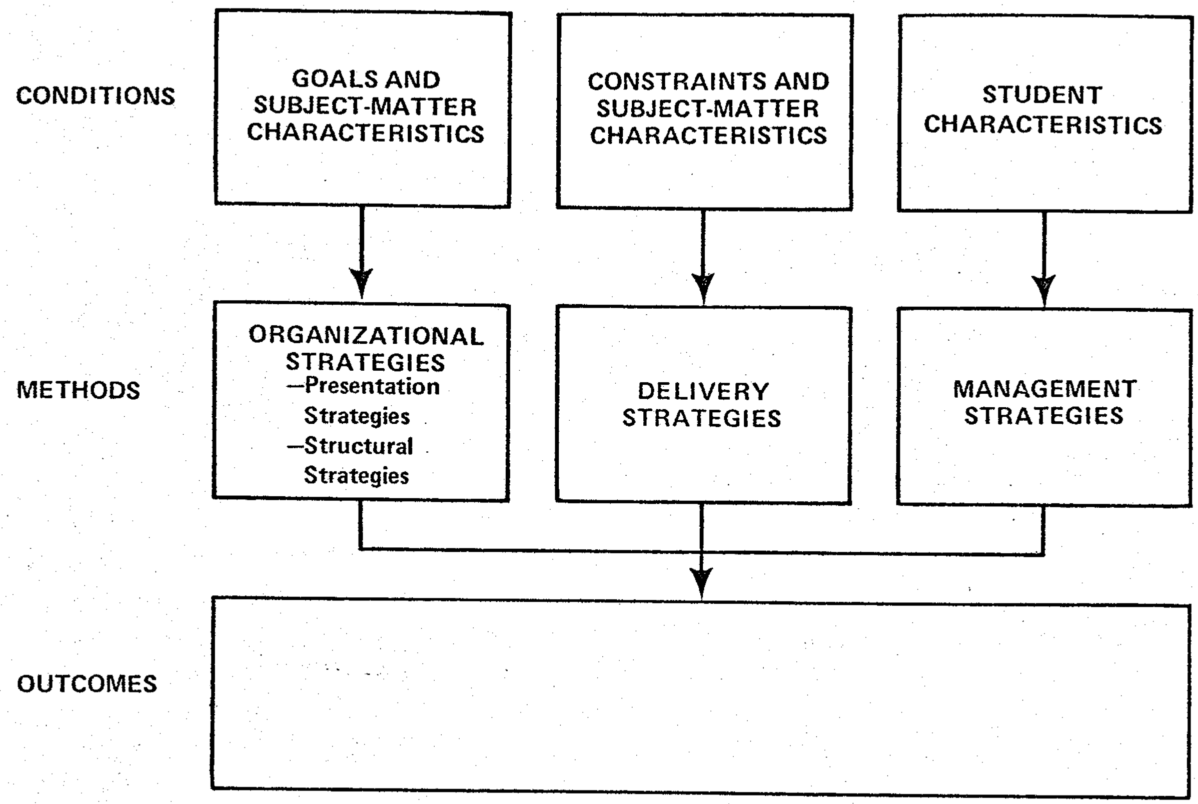


Figure 3. A model showing classes of instructional variables and the major relationships among them. Condition variables are broken into three classes according to their major influences on the classes of instructional method variables.

more referents of one or more concepts, which are referred to as "range concepts." And *an OPERATION describes a particular mapping between a domain and a range.* An operation, when applied to instances of the domain concept(s), results in the selection of corresponding instances of the range concept(s). (See Figure 4.) The overall construction (i.e., the domain, operation, and range taken together) is referred to as a *content construct.* It will become apparent from the examples provided below that constructs are, in effect, made up of other constructs, for domain and range concepts are themselves constructs, each of which has its own domain, operation, and range.

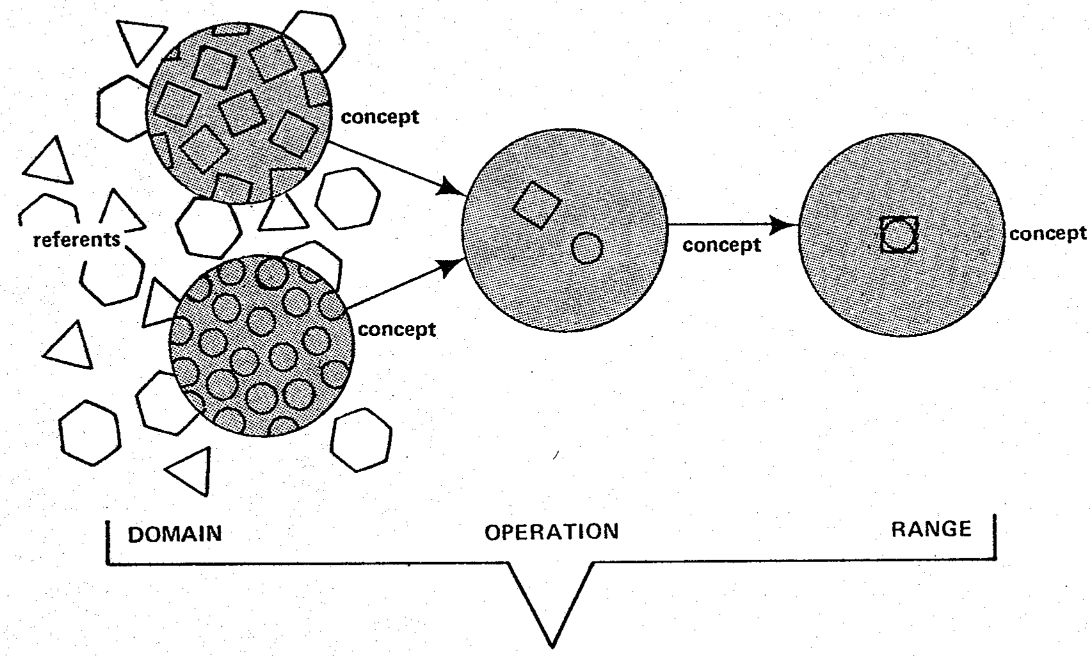
However, in addition to comprising other constructs, constructs may be grouped into a structure on the basis of a single pervasive relation among those constructs (Reigeluth, Merrill, and Bunderson, 1978). This single pervasive relation is similar to an operation, except that (1) the range of one construct serves as the domain of another construct, and (2) the pervasive relation serves as the operation for all constructs in the structure. An example of a structure is provided below.

Returning to our classification of subject-matter variables, the above-described conceptualization of subject matter leads to its classification as referents, constructs, structures, and multi-structures, each of which is a "set" of members of the previous class (i.e., a construct is a set of referents, a structure is a set of constructs, etc.).

- *Referent*: An object, event, or symbol which exists in our real or imagined environment.
- *Construct*: A single domain, operation, and range taken as a unit. It is a set of referents.
- *Structure*: A "multiple-construct" in which the range of one construct is the domain of another construct having the same kind of operation. This single, pervasive kind of operation is referred to as a *relation.*
- *Multi-Structure*: A "multiple-structure" in which the relations among two or more structures are shown.

Referents. Instruction never takes place at the level of an individual referent; the closest it gets is

COMPONENTS OF SUBJECT MATTER



REFERENT (INSTANCE). A referent (or Instance) is an object, event, or symbol which exists, or could exist, in our real or imagined environment.

CONCEPT. A concept is a set of common characteristics (attributes) referenced by a particular name or label, that can be applied to a set of referents (instances of that concept).

OPERATION. An operation is a function set or a set of operators which specifies a particular mapping between a domain and a range.

DOMAIN. A domain is a set of referents upon which the operation acts or to which it is applied.

RANGE. A range is a set of referents which results from the application of an operation to a domain.

CONSTRUCT. A construct is a structure consisting of a domain, an operation, and a range.

Figure 4. The composition of a content construct.

at the "fact" level of a construct (see next paragraph). Therefore, this classification of subject matter is of no interest to us.

Constructs. The major kinds of constructs which seem to have the most utility for prescribing organizational strategies are: facts, concepts, subsets, principles, and steps of procedures. (See Reigeluth, Merrill, and Bunderson, 1978, for a more detailed description.) Figure 5 illustrates these five kinds of constructs.

- *Fact*: A one-to-one mapping between two referents (a domain and a range), such as "Columbus discovered America in 1492." A common type of fact is an *identity*, in which one referent is equivalent to the other.
- *Concept*: A class of referents (the range concept) which are grouped on the basis of certain common characteristics (the domain concepts). The operation specifies either a union ("and") or an intersection ("or") relationship among the domain concepts to form the range concept.
- *Subset*: A set of concepts which are parts or kinds of a single (superordinate) concept. The operation specifies that referents

CONSTRUCT

Fact

The symbol shown is used to represent a vacuum tube on a schematic diagram of an electronic circuit.

Subset

Parallel circuits, series circuits, and combination circuits are three kinds of circuits.

Concept

A circuit is at resonance when reactive capacitance and reactive inductance are present in equal amounts (in a series RLC circuit).

Step

To "zero" the ohmmeter:
1. Turn range selector to desired setting.
2. Touch probes together.
3. Adjust ohms control until a zero reading is achieved.

Principle

An increase in frequency in a AC circuit produces a decrease in total current and an increase in total impedance.

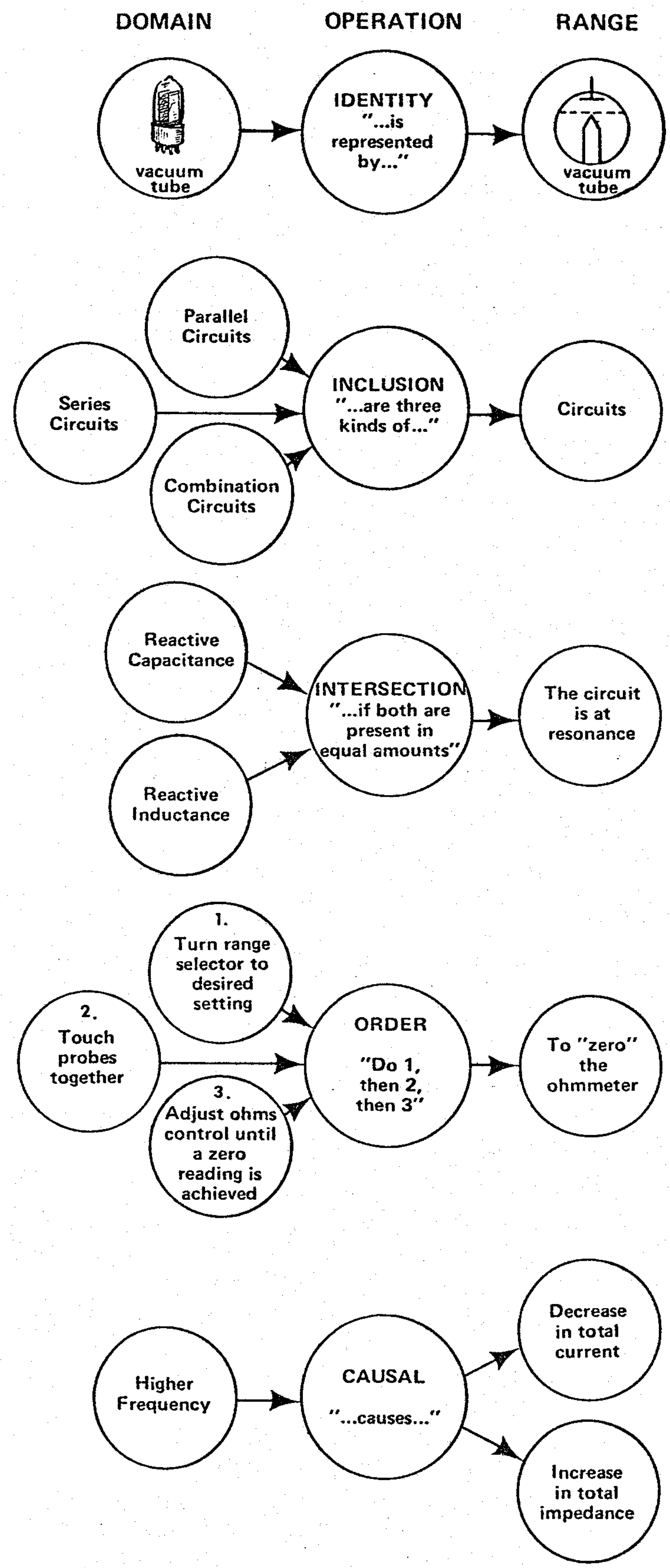


Figure 5. An example of each of the five kinds of constructs.

of the subordinate concepts (the domain concepts) are either parts or kinds of the referents of the superordinate concept (the range concept).

- *Principle*: The operation specifies a cause-and-effect relationship among several event concepts. The event concept that is the cause is the domain concept and the effect is the range. There may be more than one concept on the cause and/or the effect side.
- *Step*: The specification of specific actions to take in order to execute some clearly defined behavior or achieve some clearly defined objective. The domain concepts are event concepts which represent the actions to be taken; the range concept is the objective; and the operation is the order in which the actions should be taken.

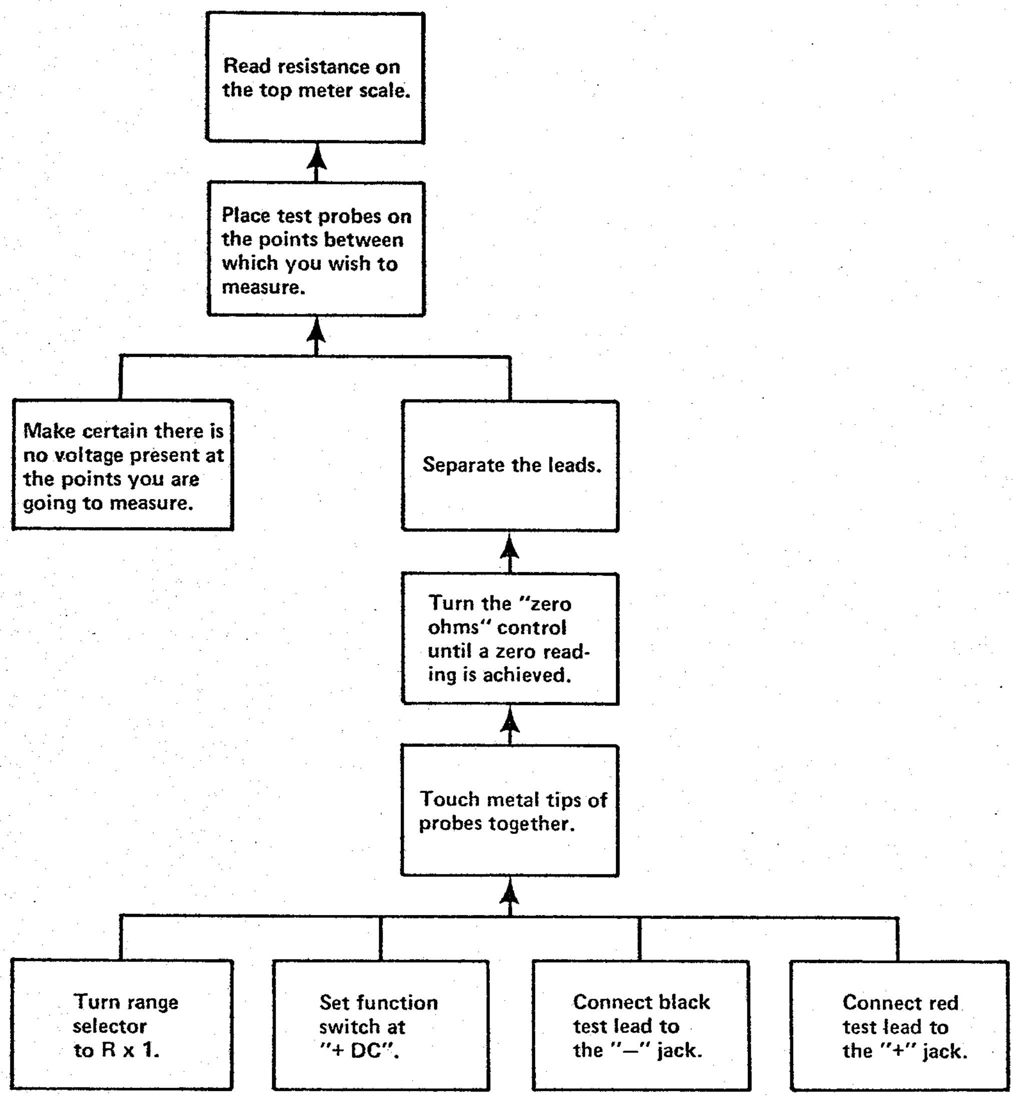
Structures. The major kinds of structures which seem to have the most relevance for organizational strategies are: lists, learning structures, conceptual structures, procedural structures, and theoretical structures (or models). (See Reigeluth, Merrill, and Bunderson, 1978, for a more detailed description.)

- *List*: A structure showing a linear (order) relation among its constructs. The nature of the linear relation may vary—for instance, countries may be listed in order of population, area, agricultural production, birth rate, or an almost infinite number of other characteristics.
- *Learning Structure*: A structure showing learning prerequisite relations among its constructs. In effect, a learning prerequisite is a *critical component*—something that must be learned before something that it is a part of can be learned. For concepts, they are referred to as critical attributes, which are also concepts. For procedures, the critical components are the steps in the procedure and/or the subprocedures which comprise different paths through the procedure (P. Merrill, 1978). For principles, they are the concepts whose interrelationships are described by the principle. Learning structures are often referred to as learning hierarchies, but we prefer to avoid that term because it has come to gain a broader meaning that includes other kinds of structures (especially parts-taxonomic structures and procedural-prerequisite structures).
- *Conceptual Structure*: A structure showing superordinate/coordinate/subordinate relations among constructs. There are three important types of conceptual structures: *parts taxonomies*, which show constructs that are components of a given construct; *kinds taxonomies*, which show constructs (usually concepts) that are varieties of a given construct; and *matrices* (or tables) which are combinations of two or more taxonomies.
- *Procedural Structure*: A structure showing procedural relations among constructs. There are also two important kinds of procedural structures: those which show *procedural-prerequisite relations*, which specify the order(s) for performing the steps of a single procedure, and those which show *procedural-decision relations*, which describe the factors necessary for deciding which alternative procedure or subprocedure to use in a given situation. See Figure 6 for an example.
- *Theoretical Structure*: A structure showing change relations among constructs. The most common kind of theoretical structure, or model, is that which shows *empirical relations*. Another important kind is one which shows *logical relations*. Klausmeier (1977) identified three kinds of empirical relations: cause and effect, correlation, and probability. He also labeled logical relations as axiomatic. One of the major tasks of any discipline is to discover or create logical structures which are isomorphic with empirical structures.

In reality, the difference between constructs and structures is not clear-cut; it is more like a continuum with a fuzzy boundary between two sides. In addition, the "push-down principle" (see Merrill, 1971; Reigeluth, Merrill, and Bunderson, 1978) can move the boundary along the continuum (toward the construct side) as the learner deepens his/her understanding. Nevertheless, given its variation with the learner's level of knowledge, the distinction between constructs and structures is a useful one for prescribing different types of organizational strategies.

Multi-Structures. There are at least two kinds of multi-structures that are important for prescribing organizational strategies: nested and parallel.

- *Nested Multi-Structure*: A multi-structure comprised of structures which have a construct in common. For example, imagine a theoretical structure in a horizontal plane. Each construct in that theoretical structure could be the top box in a different learning structure. See Figure 7 for an example.
- *Parallel Multi-Structure*: A multi-structure consisting of two or more structures which have no concepts in common, but which have consistent relations between their respective concepts. For example, imagine



Key: The arrow between two boxes on different levels means that the lower box must be performed before the higher box can be performed. Boxes on the same level can be performed in any order.

Figure 6. An example of a procedural-prerequisite structure.

a theoretical structure and a procedural structure in parallel planes. Each step in the procedural structure is related to (and, in fact, was probably derived from) a corresponding principle in the theoretical structure.

Turning now to the other major class of condition variables that relate to organizational strategies, *instructional goals* can be classified into two kinds, corresponding to the two kinds of organizational strategies (structural and presentation). These are referred to as general goals and specific objectives.

- *General Goal*: A general statement about what the results of the instruction should be. It applies to a large section of subject matter (i.e., a whole structure or multi-structure) rather than to an individual construct.
- *Specific Objective*: A specific statement about what the results of a part of the instruction should be. It applies to a single construct or to a small set of closely related constructs, rather than to a large section of subject matter.

General Goals. We propose that there are two

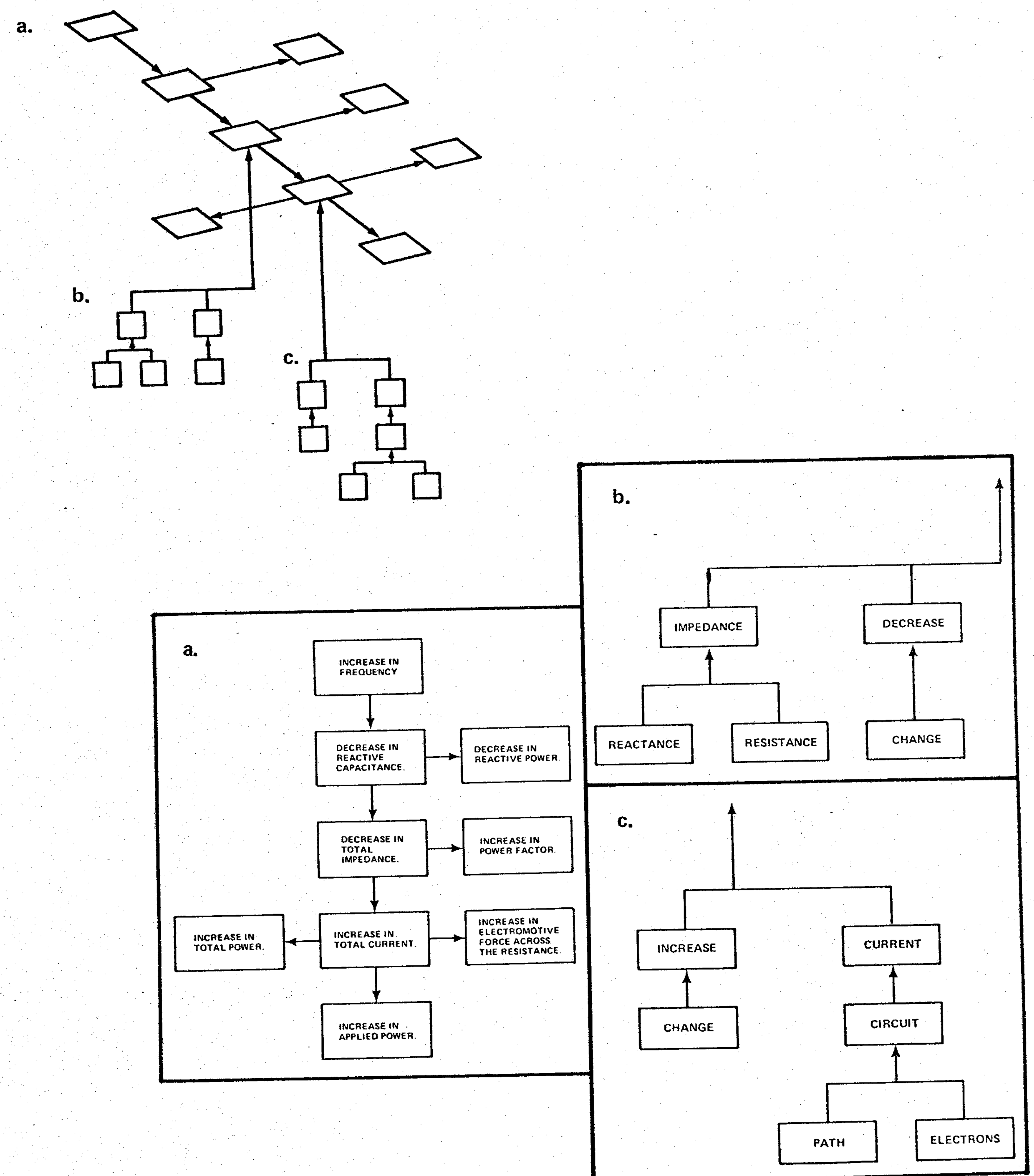


Figure 7. *Part of a nested multi-structure showing two learning prerequisite structures as supporting structures for a theoretical orientation structure.*

kinds of general goals that have particular value for prescribing structural strategies: orientation goals and supporting goals.

- *Orientation Goal*: The major emphasis of the instruction, with respect to how the student will use the subject-matter content.
- *Supporting Goal*: A specification of subject-matter content and student behaviors that will enable or facilitate the achievement of the orientation goal.

Further, we propose that it is useful to classify all *orientation goals* as conceptual, procedural, or theoretical.

- *Conceptual Orientation Goal*: The major emphasis of the instruction is for the student to gain a firm understanding (a) of the important concepts in a subject matter and (b) of the important taxonomic relations among those concepts. This is, in essence, a "general education" approach.
- *Procedural Orientation Goal*: The major emphasis of the instruction is for the student to learn to perform a procedure or a set of procedures.
- *Theoretical Orientation Goal*: The major emphasis of the instruction is for the student to understand the important change relations in a subject matter. This type of orientation goal may also be performance-oriented, but the performance entails broad transfer to unfamiliar situations that only a fundamental understanding of underlying processes would be adequate to cope with.

Supporting goals, which are less general than orientation goals but are still useful for prescribing structural strategies, may be classified as enabling, contextual, procedural, and explanatory.

- *Enabling Supporting Goal*: A supporting goal which indicates what a student must know (or be able to do) in order to learn a part of the goal which it supports. An enabling goal identifies learning prerequisites.
- *Contextual Supporting Goal*: A supporting goal which requires showing the context of a part of the goal which it supports. This is in relation to subject-matter content which is super/co/subordinate to it.
- *Procedural Supporting Goal*: A supporting goal which requires showing a standard procedure related to the goal which it supports. Landa's (1974) identificational and transformational algorithms usually satisfy this kind of supporting goal.
- *Explanatory Supporting Goal*: A supporting goal which requires showing the underlying processes upon which the procedural goal it supports is based.

Specific Objectives. Specific objectives are useful for prescribing presentation strategies. Merrill has classified them on the basis of two dimensions: the *type of content* to be learned and the *task level* (i.e., level of student behavior) at which that content is to be learned (Merrill and Boutwell, 1973; Merrill and Wood, 1974; Merrill, Reigeluth, and Faust, in press).

The *type of content* has been analyzed into four types: facts, concepts, procedures, and principles. (For these purposes, subsets are lumped together with facts because the strategies for teaching them are the same.) *Task level* has been analyzed into three major types: remember an instance, remember a generality, and use a generality. (Sometimes find a generality is also included.) An *instance* is a referent, and it may be an example of a concept, an application of a procedure, or an explanation of a principle. A *generality* is a statement which applies to a set of instances, such as a definition of a concept or a statement of a procedure or principle. The two remember task levels may be further classified as to whether the remembering is to be verbatim or paraphrased. Such a distinction does have some important prescriptive utility (Merrill, Reigeluth, and Faust, in press; Merrill, Richards, Schmidt, and Wood, 1977).

When the three task levels are applied to the four content types, ten classifications of objectives are identified (see Figure 8). These task-content classifications have been shown to have considerable utility for prescribing presentation strategies (Merrill, Reigeluth, and Faust, in press; Merrill, Richards, Schmidt, and Wood, 1977).

This concludes our classification of condition variables which represent instructional goals and subject-matter characteristics. Figure 9 summarizes these classifications.

Constraints and Subject-Matter Characteristics

There are two levels of condition variables which influence the selection of delivery strategies: (1) those variables which influence the estimation of *each* of the five characteristics of media described above (fidelity of representation, interactive capabilities, other special capabilities, motivational effects, and cost); and (2) those variables which represent the institutional constraints against which *all* of those five characteristics of media are evaluated.

Each. With respect to variables which influence the estimation of each characteristic, two of the five characteristics of media described above *vary independently of conditions.* These two characteristics are (1) a medium's interactive capabilities and

TASK LEVEL	Fact	Concept	Procedure	Principle
Use a Generality		WAS THE CASE STUDY YOU JUST READ (ABOUT MR. GREEN'S BIOLOGY CLASS) AN EXAMPLE OF MASTERY LEARNING?	HOW COULD MS. SMITH USE MASTERY LEARNING IN HER ENGLISH CLASS?	HOW COULD THE USE OF MASTERY LEARNING HELP MS. SMITH IN HER ENGLISH CLASS?
Remember a Generality		WHAT IS MASTERY LEARNING? OR DEFINE MASTERY LEARNING.	WHAT MUST A TEACHER DO TO IMPLEMENT MASTERY LEARNING IN HIS OR HER CLASSROOM?	WHAT ARE THE MOST IMPORTANT EFFECTS OF MASTERY LEARNING? OR WHAT IS THE RATIONALE FOR MASTERY LEARNING?
Remember an Instance	MR. BROWN TEACHES THREE CLASSES, OR MR. BROWN DOESN'T USE MASTERY LEARNING VERY WELL.	IS MR. BROWN'S CLASS AN EXAMPLE OF MASTERY LEARNING? (WHERE THE STUDENT WAS PREVIOUSLY TOLD THAT IT IS.)	WHAT DID MR. BROWN DO TO IMPLEMENT MASTERY LEARNING IN HIS CLASSROOM?	WHAT WERE THE RESULTS OF MR. BROWN'S USING MASTERY LEARNING IN HIS CLASSROOM LAST YEAR?

CONTENT TYPE

Figure 8. The profile's task-content classification table for classifying objectives, test items, and instructional presentations.

CONDITIONS

SUBJECT-MATTER CHARACTERISTICS

Referents

Constructs

Facts
Subsets
Concepts
Principles
Steps

Structures

Lists
Learning structures
Conceptual structures
Theoretical structures
Procedural structures

Multi-Structures

Nested
Parallel

INSTRUCTIONAL GOALS

General Goals

Orientation Goals

Conceptual
Procedural
Theoretical

Supporting Goals

Enabling
Contextual
Procedural
Explanatory

• Specific Objectives

Content Type
- Fact
- Concept
- Procedure
- Principle

Task Level
- Remember an instance
- Remember a generality
- Use a generality

Figure 9. A summary of the classifications of the condition variables that influence the use of structural strategies.

(2) a medium's cost. A medium's interactive capabilities can be varied with the use of imaginative planning. For instance, films could be made somewhat interactive with the use of several projectors per person, allowing for some flexibility of choice or branching. A medium's cost can also be varied by varying design. Sound film can be done very inexpensively with a super-8 sound system and student volunteer personnel, or it could be done very expensively with highly professional animation and special effects.

The other three characteristics of media—fidelity of representation, special capabilities, and motivational effects—are all affected primarily by *subject-matter characteristics,* but may also be affected to some extent by *some other condition variables.* It is likely that the motivational effects of a medium vary with some student characteristics as well as with some subject-matter characteristics, but it is likely that the effects of special capabilities of a medium and of the fidelity of representation of a medium vary almost exclusively with subject-matter characteristics.

All. With respect to variables that influence all of the five characteristics of media described above, institutional constraints appear to be of almost exclusive importance. These constraints are based on limitations of money available, but they are often manifested as limitations of such resources as personnel and equipment. Time limitations may also constrain to some extent the selection of parameters of the delivery strategy variables (e.g., there may not be enough time to develop a flight simulator before the first pilots need to be trained).

Student Characteristics

We hypothesize that student characteristics are the condition variables that have the largest influence on the selection of management strategies. Much research has been done recently on the interactions between student characteristics (often referred to as "aptitudes") and various kinds of instructional methods (Cronbach and Snow, 1977). But, unfortunately, little work has been done on distinguishing different kinds of "aptitude-treatment interactions" (ATIs). Much of the ATI research on organizational strategies has been ambivalent and sometimes even contradictory. We propose that it will be much more fruitful to investigate ATIs with management strategies, and that some of those ATIs will be highly consistent and powerful.

We propose that it may be especially fruitful to investigate ATIs with strategies for scheduling organizational strategy components, such as when a student should see which organizational strategy components, and how long (or how many/much) a student should use each component. For instance, we know that concept-classification instruction should include matched nonexamples, but decisions as to when a student should study a matched nonexample and for how long he/she should study matched nonexamples probably vary with certain student characteristics. We also know that an alternative representation of a generality should be available to a student, but decisions as to whether and when to study that alternative representation probably vary with certain student characteristics.

We hypothesize that there are four major classes of student variables that influence the selection and effects of management strategies: (1) ability variables, (2) motivational variables (these are distinct from the motivational variables discussed above in that these are conditions and the ones discussed above are manipulatable methods), (3) self-concept variables, and (4) handicap variables.

Ability Variables. We propose that student ability variables lie on a qualitative continuum as well as their having a quantitative dimension. This qualitative continuum ranges from abilities that are highly trainable (such as subject-matter competencies) through abilities that are trainable over longer periods of time, and to a lesser degree (such as many learning skills) to abilities that are very difficult to influence, even over long periods of time. The serialist-holist distinction and the visual-verbal distinction are two ability variables that may have a particularly important influence on management strategies.

Motivational Variables. We propose that there is a continuum of basic kinds of motivational variables which influence management strategies, ranging from *pervasive* variables, which have pervasive effects across subject matter and across time, to *specific* variables, which have local and temporary effects. Pervasive motivational variables include such things as career goals, level of general aspirations, and degree of perfectionism. Specific motivational variables include such things as the momentary need for efficiency (e.g., a student's girlfriend is waiting for him ouside).

Self-Concept Variables. This class of student variables includes such things as anxiety and confidence.

Handicap Variables. There are at least two basic kinds of handicap variables that influence management strategies: (1) physical handicaps, such as lack of one or more senses (blindness, deafness, etc.) or lack of motor coordination (e.g., paralysis), and (2) psychological handicaps, such as various kinds of neuroses or various kinds of mental deficiencies.

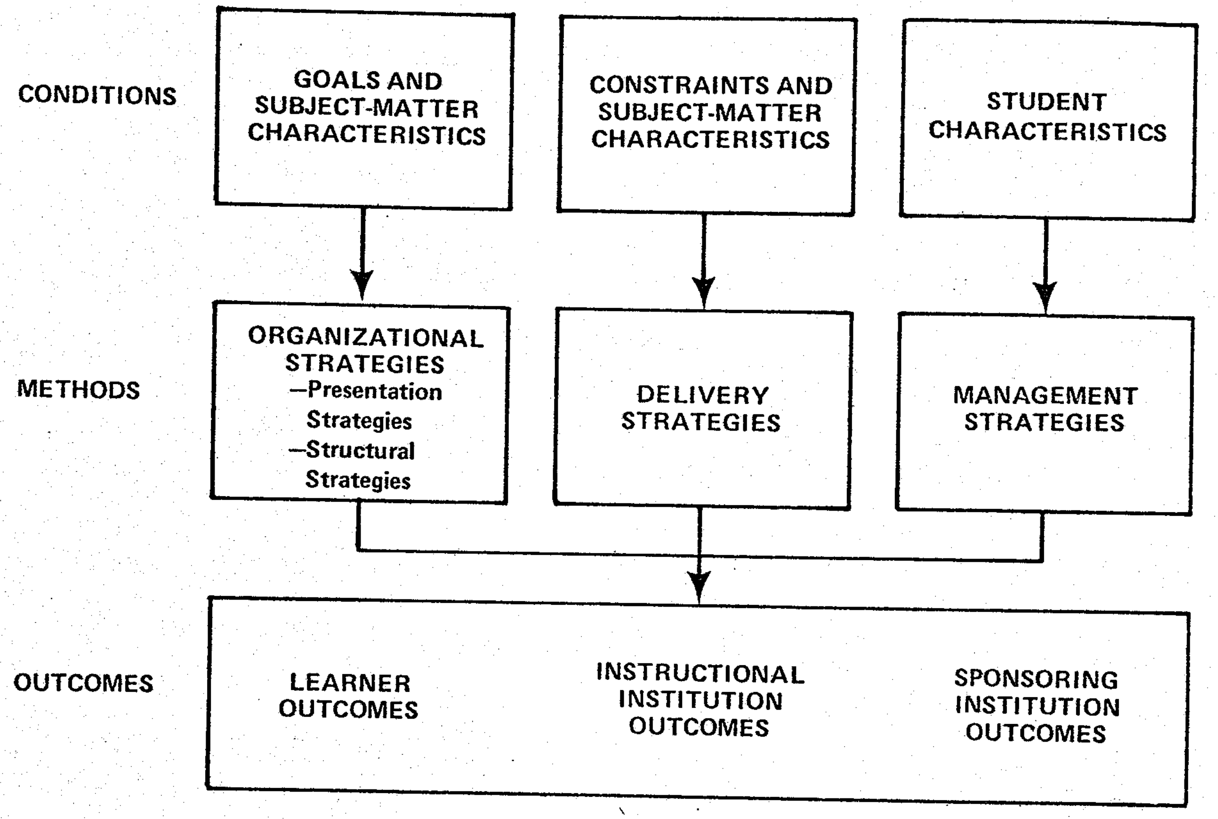


Figure 10. A model showing classes of instructional variables and the major relationships among them. Outcome variables are broken into three classes.

OUTCOMES

Having elaborated on both instructional method variables and instructional condition variables (see Figure 10), we will now describe and classify the outcome variables by which one can measure the value of different methods under different conditions. This class of variables includes all outcomes of interest (1) to the *learner,* who may be of such diverse types as a preschooler, a pilot, a drywall worker, or a medical student, (2) to the *instructional institution,* which may be of such diverse types as a public elementary school, a private boarding school, the army, a private company, or the learner himself/herself, and (3) to the *sponsoring institution,* which may be of such diverse types as a community, parents, a private company, the army, or the learner himself/herself.

Learner Outcomes

Learner outcomes can be classified as to three types: effectiveness, efficiency, and appeal of the instruction.

Effectiveness. There are four important aspects of the effectiveness of instruction: (1) the *accuracy* of the student's learned behavior (often referred to as "error rate"), (2) the *speed* with which the student can perform the behavior (often referred to as "performance efficiency," (3) the *degree of transfer* of which the student is capable, and (4) the *length of retention* of the learned performance.

These four aspects of effectiveness are all continua which form a four-dimensional space for describing the effectiveness of some instruction. Figure 11 shows a two-dimensional description of effectiveness as a curved line, using performance accuracy and speed of performance, which are inversely related. Any two dimensions could be described together in a similar manner. One could also envision a curved plane showing how the curve in Figure 11 would change with increasing degrees of transfer, or alternatively with increasing length of elapsed time between the instruction and the test (retention). It is likely that a catastrophe theory "cusp" (Zeeman, 1976) exists at some point along the retention axis.

It is important to remember that effectiveness

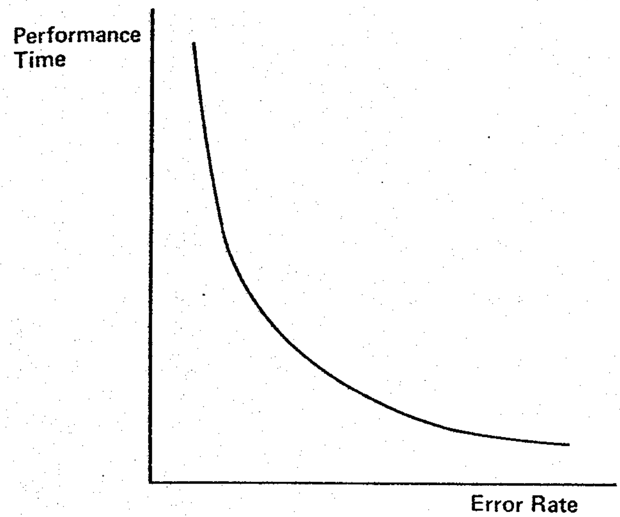


Figure 11. A two-dimensional description of effectiveness, using performance accuracy (error rate) and speed of performance (time) as the two dimensions.

must be measured in relation to the goals and objectives of the instruction. This consideration introduces such aspects of effectiveness as *what* was learned (e.g., constructs vs. relations, or conceptual understanding vs. performance efficiency), *how much* was learned (e.g., how many constructs, how many relations), and *on what level* it was learned (e.g., recognize vs. recall and identify vs. produce).

Efficiency. There appears to be only one aspect of efficiency that is important to the learner—that which relates to *learning time.* This can be expressed as the amount of effectiveness per unit of the learner's time. Another expression of the efficiency of instruction is "trials to criterion," which many people confuse as a measure of effectiveness.

Appeal. The appeal of the instruction can be closely related to the appeal of the subject matter, in that the quality of the instruction will usually influence both. Therefore, there are two basic types of outcome variables which measure appeal: those which relate to the *instruction* and those which relate to the *subject matter.*

Two important variables for measuring appeal are *appreciation* and *desire for more.* Each of these can be applied to either instruction or subject matter. In the case of instruction, there are measures of a learner's appreciation of each strategy component and of the instructional method as a whole, and there are measures of a learner's desire to have the same strategy components on similar material. And in the case of subject matter, there are measures of a learner's appreciation of the subject matter, and there are measures of his/her desire to apply or to learn more about the subject matter.

Instructional Institution Outcomes

Instructional outcomes that are of importance to the institution doing the instructing include four types: (1) learner outcomes, (2) monetary costs, (3) management demands, and (4) appeal to personnel.

Learner Outcomes. The learner outcomes are those that were just described above: effectiveness, efficiency, and appeal. These outcome variables are of importance to the instructional institution because they are the output by which that institution is evaluated. To some extent, that institution's existence is dependent on the quality of that output.

Monetary Costs. The monetary cost of the instruction is another important outcome for the instructional institution because that institution cannot survive long if its costs exceed its revenues. If the instruction's costs are too high, it is unacceptable, just as it is unacceptable if its learner outcomes are too low.

Management Demands. The management demands of the instruction are another important outcome of the instruction for the instructional institution. The instruction cannot be properly implemented if its management demands exceed the capabilities of the institution.

Appeal to Personnel. Whether or not the people who help in the delivery of the instruction find their work appealing is another important outcome for the instructional institution. The degree of importance of this outcome varies with the nature and extent of the people's interactions with the learners.

Sponsoring Institution Outcomes

Instructional outcomes that are of importance to the institution sponsoring the instruction include three types: (1) learner outcomes, (2) monetary costs, and (3) appeal of the attained objectives to the institution itself.

Learner Outcomes. The learner outcomes are those that were described above: effectiveness, efficiency, and appeal. These outcomes are important to the sponsoring institution because they are the major, if not the sole, purpose for its paying for the instruction.

Monetary Costs. The cost-effectiveness of the instruction is another important outcome of the instruction for the sponsoring institution. If the instruction's costs are too high in relation to its

	Learner Outcomes	Instructional Institution Outcomes	Sponsoring Institution Outcomes
OUTCOMES	**Effectiveness** —accuracy —speed —transfer —retention **Efficiency** —learning time **Appeal**	**Learner Outcomes** —effectiveness —efficiency —appeal **Monetary Costs** **Management demands** **Appeal to personnel**	**Learner Outcomes** —effectiveness —efficiency —appeal **Monetary costs** **Appeal to sponsor**

Figure 12. A summary of the outcomes by which instructional methods should be evaluated under different conditions.

benefits, the sponsor will no longer be willing to pay for the instruction.

Appeal. The degree to which the attained objectives and conditions of the instruction appeal to the sponsoring institution is an outcome of considerable importance. If it does not appeal to the sponsoring institution, then the sponsor may cease to pay for the instruction.

Figure 12 summarizes the outcomes by which instructional methods should be evaluated under different conditions.

SUMMARY

We have described the classes of variables which we believe should be considered when one is designing instructional materials, doing research on instruction, or developing better methods of instruction (theory-construction). Familiarity with these classes can help *instructional designers* by indicating what sorts of strategy components should be included in their designs and what sorts of conditions may influence how and when those strategy components should be used. It can help instructional scientists, such as *researchers* and *theory builders*, by indicating important kinds of variables that should be investigated or included in one's theories. It also helps provide a common and unambiguous terminology for describing the instructional process.

Figure 13 summarizes the entire classification scheme described in this article. The usefulness of this classification scheme can only be determined by investigating the stability, magnitude, and meaningfulness of the cause-and-effect relationships among its classifications. Some work has already been done on postulating and testing such causal relationships (Merrill, Reigeluth, and Faust, in press; Merrill, Richards, Schmidt, and Wood, 1977; Reigeluth and Merrill, 1978; Reigeluth *et al.*, 1978), but a majority of work remains to be done in this area. □

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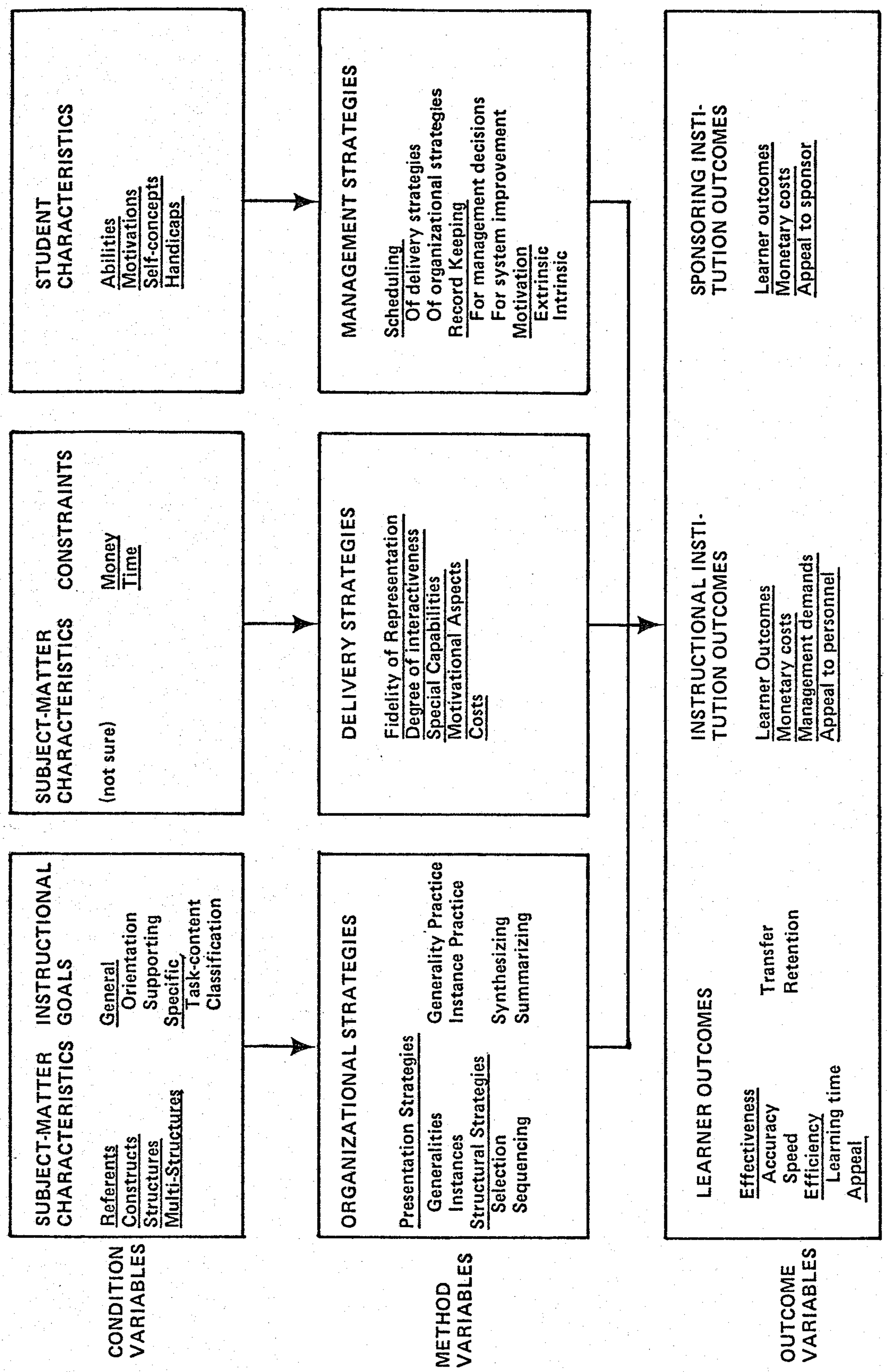

Figure 13. A summary of the entire classification scheme for instructional variables described in this article.

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