BEHAVIORAL ANALYSIS FOR PROGRAMMERS

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1. ABOUT BEHAVIORAL ANALYSIS

The Objective of Behavioral Analysis

In the development of instructional materials, the objective of behavioral analysis is to answer the question "Given the test item in the terminal behavior specifications, what aspect of the behavior specified could present a problem to the trainee, i.e. what aspects of the behavior does he not yet know and therefore needs to learn?" Thus the end product of a behavioral analysis is a specification of the discriminations, generalizations, and chains the trainee needs to learn. The end product is a guide for the construction of instructional material and sequencing it, in the production of an initial version of a training system.

Consequences of Inadequate Behavioral Analysis

Training materials based on inadequate behavioral analysis are dull and waste the trainee's time, sometimes by teaching trivial material that he already knows, and sometimes by failing to teach vital concepts and building blocks required for smooth and solid progress. Many programmed instruction materials on the market provide good illustrations of the result of inadequate behavioral analysis. Such materials ask the student to make trivial responses, like writing out words or phrases that he already knows very well how to write, and generally to answer questions that are not relevant for the new material to be learned.

Source of Behavior to Analyze

The behavior to be analyzed is that which was described and exemplified in the terminal behavior specifications whose purpose is to specify the behavior that must be made to occur, so that it

can be analyzed and specified. It is clear that not all of the behavior described and exemplified in the test item needs to be learned by the trainee. Much of the behavior may already be in his repertoire. As was stated above, the point of behavioral analysis is to determine which of the concepts and chains are critical, new, and difficult for the target population for which the training system is destined, and to specify these concepts and chains.

Status of Behavioral Analysis

Behavioral analysis has become important as a consequence of the growing practical significance of educational technology and the development of training systems. In order to develop effective and efficient training materials that maintain the student's interest and motivation, a correct analysis of the behavior being learned is essential. The behavioral analysis specifies the units that need to be assembled and made part of the student's behavioral repertoire.

Concepts and chains are the most useful kinds of units for assembling and building behavior. Concepts are made up of discriminations and generalizations, as will be explained below (See also Supplement III to "Programming for Automated Instruction"). Therefore, the task of behavioral analysis is to identify the critical and most important discriminations, generalizations, concepts, and chains.

There are a few questions one may ask regarding the value of behavioral analysis: "How do we know what kinds of units to use in analyzing something as complex as knowledge? After all, every area of knowledge has its own peculiarities and organization, and every individual, when he learns, tends to organize knowledge in

a way that is peculiar to his own intellect and way of thinking. Therefore, how can we presume to impose one mode of analysis on all knowledge and on all individuals who may want to assimilate this knowledge?"

An analogy may help answer this question. Consider the structure of matter as an analogue of the structure of knowledge. There are billions of types of materials in the world, including wood, air, flesh, alcohol, and dust. And yet they are all made up of only about one hundred kinds of atoms, in various arrangements. Chemistry allows us to understand the atomic structure of matter so that we may know how to build it and take it apart. The numerous combinations and arrangements of the atoms account for millions of different kinds of materials. Furthermore, even though any given material has only one particular composition of atoms, different chemists, because of their different skills, tools, and personalities, will use different methods for synthesizing or building any given substance or material. And yet, the atomic analysis is useful to all of them.

Extending this analogy to behavioral analysis, it is evident that the use of a limited number of categories, or components of knowledge or skill, does not necessarily imply a limited number of kinds of knowledge or skill. Also, the fact that the number of components is limited does not mean that every learner must assimilate or "build" the knowledge or skill in the same way. Each learner assembles knowledge or skill in a way that suits him, but the final configuration reflects the particular knowledge or skill involved.

Are there any alternative ways of analyzing knowledge, any competitive system of units or components, deriving from a discipline other than behavior theory or learning theory? The answer is, yes, many. Not too long ago, there were also quite a

few alternative systems of units in chemistry. Some that are still remembered are the air-fire-water-earth system, phlogiston, and vis viva. But chemists did not find these concepts useful as analytic units for the purpose of analyzing and synthesizing substances and were, therefore, eventually replaced by the atomic theory, which proved much more useful.

In the field of education and training, there are also quite a few systems other than the one derived from learning theory. Some of the more familiar units or entities are: cognitions, insights, ideas, facts, information, statements, and principles. But useful thought these may be for communication purposes, they are not useful for analyzing and building skills and knowledge. This is not to say that they do not refer to anything "real" or important, just as air, fire, water, and earth refer to "real" and important things. Similarly, such entities as cognitions, insights, facts, and so on, refer to real and important things, but this fact does not make them useful as analytic units for purposes of analyzing and building any kind of skill or knowledge. For this function they are not useful, while the units provided by learning theory are.

Types of Behavioral Analysis

Different types of behavior require different approaches to behavioral analysis. Examples of different types of behavior would be: performing on a musical instrument, verbal knowledge, manual skills, language learning, visual observation skills, sports, dance, interpersonal relations, tolerance of various types of stress, and behavior patterns like curiosity, patience, or perseverance. All of these can be analyzed in terms of concepts and chains. Differences between them include the types of stimuli involved in the discriminations and generalizations they

involve. The present discussion will deal principally with the behavioral analysis of the kind of behavior that is important in most training systems, and will not attempt to encompass all of the types of behavior listed above.

2. CHAINS AND CONCEPTS

Concepts

A person is said to "have" or to "know" a concept when he is able to make certain discriminations between classes and generalizations within classes. To understand what a concept is and how behavior can be analyzed in terms of concepts, it is therefore necessary to understand discriminations and generalizations.

Discriminations

"Discrimination" is the technical term for what is commonly called "distinguishing," "categorizing," or "telling apart." Discrimination could be defined as "making one kind of response in one kind of situation or to one kind of stimulus, and another kind of response in another kind of situation."

It is understood that the terms "stimulus" and "response" are used here in the technical sense. A stimulus can be as simple or complex as one might desire. For example, a social situation in which there are several people who have had various elaborate histories with respect to each other, and who have just made certain comments, can be considered a "stimulus." The components of that stimulus include the histories of the people with respect to each other, the physical appearance of the people, and the comments that have just been made. An individual's "response" in

that situation can be an action as simple as a wink of the eye, or as complex as an extended verbal statement. Other kinds of stimuli are words on a printed page, information a person possesses, or the person's own perception of his own immediately preceding actions. Anything that is perceived, with or without awareness, and regardless of whether the perceived stimulus is simple or complex, can be considered a stimulus for behavioral analysis purposes.

Note the fact that the definition of "discrimination" given above still leaves open the question of whether the discrimination is the desired or appropriate one. Discriminations may be correct or incorrect, desirable or undesirable, according to any of various possible criteria. When we talk about desired discriminations we speak of "ability to make a discrimination" or "ability to do or say the appropriate thing at the appropriate time." Psychologists also speak of "multiple discriminations." A discrimination is "multiple" if it involves more than two kinds of responses and stimuli. Knowing the alphabet is a multiple discrimination because it entails being able to make 26 kinds of responses to 26 kinds of stimuli. Naming all kinds of animals is another examples of a multiple discrimination.

Here are some other examples of simple discriminations:

a) Saying "good morning" before noon and "good afternoon" after noon;

b) Proceeding when the light is green, and not proceeding when it is red;

c) Drawing or writing appropriate labels on the appropriate parts of a diagram;

d) Carrying one when the subtrahend is greater than the minuend and not carrying one when the subtrahend is equal to or smaller than the minuend.

Generalizations

"Generalization" is the technical' term for what is more commonly called "seeing similarities," "grouping together," "classifying," (although classifying involves both discrimination and generalization), "associating things with each other," "noticing common elements," and "disregarding differences." Again, a generalization can be appropriate or inappropriate, desirable or undesirable. When speaking of generalizations we are trying to teach, we tend to say "ability to see similarities", "ability to notice common elements", etc. Generalization could be defined as "making the same kind of response to different stimuli". Here are some examples of common and "correct" generalizations:

a) Saying "good morning" to all kinds of people (generalizing among people) regardless of what time of day it is so long as it is before noon (generalizing among different times of day before noon, and discriminating between times before noon and times after noon);

b) Proceeding when the traffic light is green, regardless of how the light is suspended, whether the subject is in a car or on foot, and whether it is morning, noon, or night;

c) In an anatomical drawing, labeling the heart with the word "heart" regardless of whether it is drawn in black and white or in color, large or small, shaded or unshaded;

d) In subtraction, carrying one when the subtrahend is greater than the minuend regardless of how much greater it is and regardless of the specific numbers involved;

e) Recognizing a person whether that person is seen from near or from afar, in light or dark, silhouette or full light, from the front or in profile.

In general, a generalization involves making the same or similar responses to stimulus situations that have something in common, in spite of differences between them. When an individual is capable of making generalizations within classes, such as those used in the above examples, and discriminations between classes, we say that he has a concept. This is the broadest possible definition of concept, and the one used by learning theorists. It has the advantages of being precise, general, and useful for the purpose of teaching any kind of concept. Once a particular concept has been analyzed in terms of its component discriminations and generalizations, we can proceed to teach that concept by teaching the discriminations and generalizations of which it consists. Learning theory gives us many practical and effective strategies for teaching discriminations and generalizations, and we then have the choice of which ones to use.

It should be clear from the above definition of concept that a concept can be simple or complex, concrete or abstract. Highly abstract concepts such as "emptiness," "space," "love," or "beauty" also lend themselves to analysis into component discriminations and generalizations, except that the stimulus situations involved are more varied and complex, as evidenced by the many years it takes a child to develop these concepts fully and to "understand" them, as we say.

Chains

"Chain" is the technical term for what is sometimes called "procedure," "process," "routine," "sequence of actions," "thought process", "reasoning process", "operation or series of operations", etc. A formal definition of a chain is "a sequence of responses in which each response produces the stimulus for the next response.

There are all kinds of chains. Each response in a chain can take anywhere from a fraction of a second to days or longer. For example, when executing the chain of writing familiar words, each finger movement with the pen produces stimuli for the next finger movement, many times a second. The stimuli involved in writing familiar words are proprioceptive (from inside the muscles and joints), visual (when you look at the marks being made by the pen), and mental (thinking about what you are writing). By a simple experiment you can show the relative importance of these three sources of stimuli. Try to write the sentence "I am writing a sentence" without looking at the paper. It is possible but difficult. You miss the visual stimulus component produced by each response in the chain. Next, try to preserve the visual and verbal component but eliminate the habitual proprioceptive stimulus component. The habitual proprioceptive stimuli can be eliminated by writing with the non-preferred hand. Next, eliminate the verbal component by engaging your voice and thought in the recitation of a familiar phrase. Without the verbal component, the proprioceptive and visual stimulus components by themselves are probably not sufficient to enable you to write the sentence.

In some kinds of chains, the stimuli are "revealed" or

"encountered" more than they are "produced" by each successive response. In reading, for example, the eye moves along the line from word to word, and as it moves, new words (stimuli) come into view. Or, in following driving instructions, each turn you take puts you on a new street and exposes you to new vistas, which are successively revealed or encountered as you drive to your destination.

Some common examples of simple chains are:

a) Tying a shoelace
b) Reciting a poem by heart
c) Uttering a sentence
d) Going through the steps of solving a math problem
e) Filling out a form
f) Making a calculation
g) Assembling a piece of equipment
h) Carrying on a conversation with another person
i) Calling "Information" to obtain a telephone number
j) Going through a thought process leading to a final decision.

This last example should make it clear that behavior can be analyzed as a chain even if the responses and stimuli comprising the chain are not overt and observable. Behavior can be overt (observable) or covert (hidden and not observable), and the same is true of chains. But even covert chains must be analyzed and specified, because the fact of their being covert once they are established and fully learned does not prevent them from being taught and learned by normal instructional methods. More about that later.

Notation for Diagramming Concepts and Chains

It is sometimes useful in doing behavioral analysis to use a notation system for stimuli, responses, discriminations, generalizations, concepts, and chains. The use of a simple notation system provides an overview of the structure and interrelationships among the stimulus and response elements within concepts and chains, and can be helpful in making sequencing decisions when the instructional materials are developed. Different stimuli and responses can be identified and distinguished by means of subscripts. An overview of the structure is also helpful in deciding on the best instructional strategies.

Note that such a notation system bears no relationship to the notation system for behavioral contingencies developed by this author in 1958 for specifying the if-then conditional relationships between behavior and its consequences.

In the diagram R → S, the stimulus S is really a stimulus complex, which can be subdivided into its components if desired. For example, suppose you drive to the end of the road and come to a street on which you can turn either right or left. You could say that the right turnoff is one stimulus and the left turnoff is another stimulus. However, we normally say that the two stimuli really constitute a single stimulus complex, designated by one letter, S. The important fact to be noted is that two alternative responses—right turn and left turn—can occur, and that each of these two alternative responses will have a different consequence. Or, if you open a drawer, and in the drawer there are three objects, you can remove one. The three objects are not considered three separate stimuli in a behavioral analysis. The stimulus situation that confronts the subject when

the drawer has been opened is designated as a single stimulus S, in which three alternative responses are possible, each one corresponding to the removal of one of the three objects. (Removal of more than one could be considered a fourth, fifth, etc. alternative response, if these possibilities are considered significant or important).

Then, there is the case where a response can produce (or reveal) any one of several possible stimulus situations. The particular response that one of several possible stimuli produces may vary from situation to situation, from case to case, and from time to time. For example, turning on the television set may result in (a) a picture appearing on the screen and the sound coming on, (b) the sound coming on without the picture, or (c) no result at all (this latter could be due to the set not being plugged into the outlet). Thus the same response can produce any of several outcomes, depending on the state of the television set. Similarly, in a social or interpersonal situation, the same comment or question can elicit many different answers or responses from the person(s) to whom it is addressed.

Chains of Concepts

When a response within a chain does not inevitably produce the same stimulus each time, but may produce (or reveal) any of several alternative stimuli, (as when the television set is turned on, or a question is asked of a person), then we are dealing with a concept within a chain, or a multiple discrimination within a chain, depending on the emphasis desired. Suppose the analyst wished to indicate only that a particular response can produce several alternative stimuli, and that only one response to one of the three several stimuli is of interest to the analysis. In such a case, the same particular response

made in the presence of other stimuli would be considered incorrect.

Chains of concepts may be among the most common types of behavior encountered in practice in the performance of behavioral analyses for training systems.

Branching Chains

When each of the stimuli in a concept (or a multiple discrimination, depending on emphasis) is the occasion for a different response, and these different responses in turn produce different stimuli, etc., the result is a branching chain.

Branching chains are encountered in diagnostic skills, decision processes, equipment trouble shooting, problem-solving tasks, debugging of computer programs, acquiring information in interpersonal questioning or conversation (such as interviewing or selling), or conducting medical examinations.

It is often difficult for the behavior analyst to remember that the diagram of a branching chain shows not what an individual actually does in a specific situation, but all the things he might do, depending on which stimulus is produced or revealed at each of the branching junctures. In any particular situation, the individual carries out one chain only.

Consider, for example, the branching chain involved in calling someone on the telephone when the caller does not have the telephone number. The first response in the branching chain might be calling "Information". The operator who answers might say any one of several things. She might say "We don't have a listing under that name", "We have several listings under that name", "Do

you have an address?", or "How do you spell the last name?" The operator's responses are stimuli for the caller, and we are concerned with the caller's behavior and not the operator's. In response, the caller could respond "It might be a new listing," or with a question he addresses to himself, such as "Do I have the middle initial or the address?" If the caller's answer to himself is "I have the middle initial," he would then proceed with the response to the operator, "The middle initial is F., do you have that listing?" If his answer to himself is "I have an address," then he proceeds with, "The address is.... Do you have a listing under that address?" If the caller's response to himself is "I have neither a middle initial nor an address," he might proceed with other types of responses.

It is clear from this example that the individual who is in the situation executes only one of many possible chains in a particular case. All the possible chains that might occur are called the "decision process", and the branching diagram that shows the possibilities is sometimes called a "decision tree." Incidentally, this example shows the usefulness and importance of including in the behavioral analysis the thought processes and decisions that occur covertly "within the person's head," so to speak.

How to Name and Designate Concepts

It may surprise the reader to learn that a concept can never be designated by a single word or phrase. Some examples will make this clear. Consider a simple-sounding and apparently obvious concept like "ship." Upon closer examination, it turns out that "ship" can refer to any of many possible concepts. Here are several:

"Ship" versus "send by airfreight" (i.e. how to send a package)
"Ship" versus "airplane", "railroad", "bus" (i.e. transportation media)
"Ship" versus "deliver by hand"
"Ship" versus "rowboat" (i.e. size of vessel)
"Ship" versus "hold till it is picked up."

The problem becomes even more serious for more abstract concepts. Consider, for example, all the concepts to which the word "love" can refer:

"Love" versus "hate"
"Love" versus "infatuation"
"Love" versus "friendship"
"Love" versus "like"
"Love" versus "mere sexual interest"

The conceptual ambiguity of a single word or phrase applies to all concepts. There is no concept that is adequately specified or designated without the "versus ..." part. That is one of the reasons for the ambiguity of ordinary language, as it is spoken and written. Every sentence is fraught with ambiguity which only the contextual constraints of the sentence and the situation can resolve. Almost every word in any sentence has a potential conceptual ambiguity. To resolve such ambiguity, underlining is sometimes used in the written mode, and oral stress is sometimes used in the spoken mode. To illustrate the conceptual ambiguity issue, let us consider a simple sentence: *Johnson is the President of the United States*. Observe how the meaning changes according to which word is underlined:

<u>Johnson</u> is the president of the United States. This means that Johnson, as opposed to somebody else, is the president.

Johnson <u>is</u> the president of the United States.
This could mean "is" versus "is not", which would be said if two people were arguing as to whether Johnson is or is not the president. Or it could mean is versus was, or is versus will be.

Johnson is <u>the</u> president of the United States.
Stressing "the" could mean "the one and only" versus "one of the," or "the" versus "a" president.

Johnson is the <u>president</u> of the United States.
This could mean president versus vice president, or president versus king, and many other possible distinctions.

Johnson is the president of <u>the United States</u>.
The stress on the United States could mean versus Canada, etc.

This analysis can be applied to any sentence, and it is amusing to observe how the meaning of any sentence can changes according to which word is underlined for conceptual stress. Note that underlining a word in a sentence does not eliminate all ambiguity as to what concept is intended. It merely identifies the word that refers to the important or significant concept in the sentence. But it does not resolve the remaining ambiguity as to which of the many possible versus's are intended. Usually the reader or listener can guess which it is when the crucial word is stressed, and underlining is all the help he may needs to understand the writer's intended meaning. The good writer knows how to anticipate the ambiguities the reader may experience when reading a sentence, and may anticipate and avert these by the way he constructs the sentence, juxtaposes it with other sentences, stresses the critical concepts by underlining, or in other ways.

In behavioral analysis, however, devices such as these are not sufficient. When a concept is identified as important, the analysis document must always define it by means of the "versus..." part, usually in parentheses after the name of the concept. The behavior analyst must never refer to a concept by its name alone. There are several good reasons for this rigid-sounding requirement.

The main reason relates to the need to identify the concept clearly. As was explained above, the concept has not been stated or defined if the "versus..." part has not been made explicit.

The second reason is that the analyst may feel certain he knows what concept he means when he uses the name by itself, but upon being challenged, it may turn out that he really does not know what he means. If he has to think upon being asked "X versus what?" this is evidence that he was not completely clear as to which concept he had in mind when he used merely its name.

The third reason is that the analyst, upon specifying the "versus..." part of the concept, may decide (and often does) that the concept is too trivial and simple to bother with. If he cannot think of a good non-trivial "versus...", that is probably because there <u>is</u> no good, worthy "versus..." or that any "versus..." he can think of is too trivial and obvious for his particular target population.

More will be said in later sections concerning the consideration of target population and other factors in deciding which concepts are trivial and which are not. Suffice it to say at this point that not every concept needs to be taught. In fact, very few concepts are sufficiently critical and relevant to warrant inclusion in the behavioral analysis. The point being made here

is that the behavior analyst makes a decision for each identified concept as to whether or not to include it in the analysis. To make sure he does not miss any important concepts, he can use the technique of underlining different words or phrases in the material he is analyzing, and coming up with the "versus..." parts that might be applicable. Based on the triviality or non-triviality of the "versus..." parts he thinks of, he either includes or leaves out the concept for incorporation into the training system (by including it in the behavioral analysis).

Concept Hierarchies

Just as one chain can be a branch of another chain, so concepts too can be related to each other. Some concepts are subsets or parts of other concepts. Concepts that are subsets of a concept are sometimes but not always prerequisites of that concept.

For example, the concept of "average" (versus sum, median, or mode) has as prerequisites the concepts of "sum" (vs. difference) and "division" (vs. multiplication). For this example, it happens that the calculation of an average is also a chain, in which these concepts appear in sequence. This, however, is not the case for all concepts. Consider the example of the concept of "mammal" (vs. bird or fish). The definition of "mammal" is "a vertebrate that has fur, that bears its young alive, and that gives milk to its young". Here there are four pre-requisite (or component) concepts: vertebrate, fur, bear the young alive, and give milk. Vertebrate (vs. invertebrate) has as a component concept the concept of "backbone" (vs. other bones or no bones), which in turn has as a component concept "internal skeleton" (vs. external skeleton, or no skeleton). "Fur" (vs. feathers, or scales) may have no significant component concepts except perhaps "skin" (vs. membrane). "Bear the young alive" (versus lay eggs, or reproduce

by fission) may have "embryo" (versus new-born or newly hatched) as a component concept. "Give milk" (vs. give found food, or let the young feed by themselves) may have as a component concept "mammary gland" (vs. absence of mammary gland, or other glands).

Concept hierarchies are based on the logical concept of inclusion or subset, rather than on behavioral or learning theory principles. The significance of concept hierarchies for behavioral analysis resides in sequencing decisions, that the most basic concepts (the most elementary or component concepts) must be learned before the more advanced concepts, of which they are subsets, can be learned. Obvious though this may be, putting it into practice and applying it is not always simple, especially when the hierarchies have many levels or possible circularities, requiring spiral approaches to sequencing.

Most concept hierarchies are rather small and simple, and usually involve only two levels. However, even simple ones should be noted in the behavioral analysis because hierarchical relationships among concepts become important in instructional sequencing.

Arbitrariness of Units

The units that are used for chains and concepts depend on the target population. Any given chain can be divided into smaller or larger members or units, as desired, according to target population. Concepts, too, can be treated as simple stimulus-response units if the target population is advanced and sophisticated, or, for a less sophisticated target population, the same concept may need to be subdivided and analyzed as a multiple discrimination into its component concepts.

Kinds of Discriminations

Visual - e.g., appearance of the skin or of the eye of a patient, photographs, etc.

Judgment of social dynamics - e.g., in a social situation involving several people, to judge whether a type of comment is or is not appropriate, whether a person is or is not anxious, etc.

Problem solving - e.g., when to apply which algorithm, or when to apply a certain heuristic.

Complex judgments - e.g., when to use which strategy in a business situation, whether it is or is not appropriate to provide feedback in a supervisory situation, etc.

Kinds of Chains

Branching chains - e.g., diagnosis, trouble shooting, problem solving, decision processes.

Chains in which you can, and chains in which you can't go ahead if a wrong response has been made in the middle of the chain.

Chains that depend on proprioceptive or kinesthetic cues - e.g., speaking, playing a musical instrument, writing longhand, typing.

Verbally mediated chains - e.g., reasoning processes, filling out a form, making a calculation, writing a computer program.

3. RELATIONSHIP OF BEHAVIORAL ANALYSIS TO TEST ITEMS

Several test items can imply the same concept or decision tree
Several test items can imply the same chain or decision tree
One test item can require several different chains
One test item can require several different concepts
Behavioral analysis can reveal the need for concepts or chains that were not included or anticipated in the test items.

4. LEARNING SEQUENCES AND STRATEGIES FOR CONCEPTS

Matching to Sample

An example or model is presented. There may be several examples or models. The student then studies these models and examples, and bases his response on his inspection of the model.

The student may learn from the models inductively, by arriving at a generalization or rule, which he then applies; or, he may copy the examples or model responses directly.

In a commonly used type of sequence, the examples or models are first presented together with some exercises in which the student is asked to apply the model. Then, there is a series of exercises that the student is asked to do without having access to the example or model.

Inductive Learning

The student is given a series of examples, models, cases, samples, etc., which may include exercises or problems in which he makes active responses. The student is expected to derive a general principle or generalization from these examples. If he does so successfully, he is then able to apply the principle or generalization to other situations.

Definitions

When concept is simple and easy to understand, it is useful to begin with a definition or a statement of the general principle. If the concept is complex, however, the student will usually not understand the general principle or definition without having first been exposed to specific cases and examples.

Algorithms

The discrimination required by a concept may be mediated by an algorithm. This means that the student, when he encounters the situation that requires the discrimination to be made, uses a certain algorithm to make the discrimination. Application of the algorithm gives him the answer. The student therefore must learn the algorithm which may be simple and short (e.g., one step) or long and complex. An algorithm, incidentally, is a chain.

Concepts that Require Cases or Episodes as Examples

In teaching complex skills and concepts, where inductive learning is required and there are few hard rules or algorithms to go by, as in supervisory or management training, or the teaching of social and interpersonal skills, it is generally necessary to use as examples cases and episodes that simulate the real situation. Usually, the concept learning process involves first classifying the cases and episodes into certain categories, and then making a response similar to the response that would be made in the real situation.

Concepts that Require Examples and Counter-Examples

Usually, when an example presents the stimulus for a given response, it is necessary also to present, by way of contrast, stimuli that are similar but for which that response would not be correct. The concept of the counter-example has already been discussed. The counter-example may call for a different response that is also one of the set of responses being learned, or it may simply be presented as not calling for a given response. Some of the most difficult judgments that the analyst must make relate to the question of how many and which counter-examples to include.