Summary of Tiemann & Markle's Approach to Principle Applying and Strategies

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What is a Principle?

Principle is synonymous with words like "law" and "rule". A principle states how two or more concepts are related. An important difference between a "concept" and "principle" is that mastery of a concept is demonstrated differently than is mastery of a principle. Recall that mastery of a concept is demonstrated when the learner accurately generalizes within a concept class and discriminates between other concept classes. Mastery of a principle, however, is demonstrated when the learner applies the principle to concepts contained within the principle. Applying a principle enables us to make a prediction, that is, a principle functions as a discriminative stimulus for a responding, guiding you through what to do and when to do it.

Principles guide our responding by stating conditions and actions.[1] A condition is a set of discriminative stimuli that occasion a response. The response occasioned by a condition (a set of discriminative stimuli) is called the action. Just like with notation used in behavior analysis, a principle is basically just an IF-THEN statement. Like an IF-THEN statement, a principle says that when something is the case, something else also is the case. Here is an example of a principle:

Liquids pour.

Notice that this principle involves two concepts, liquid and pour, and is an IF-THEN statement even though neither IF nor THEN appears in that principle. The words IF and THEN do not need to be stated in a principle. Conditions and actions can be stated implicitly or explicitly.

[1] Behavior analysis would call this a "rule" and describes this function as "contingency specifying," meaning that it alters the function of environmental stimuli, but let's not go down that road.

Furthermore, principles always can be stated in multiple ways. Watch:

IF something is a liquid, THEN it will pour.

Saying that liquids pour is equivalent to saying that if something is a liquid, then it will pour. Principles can be stated in different ways and still function as a discriminative stimulus for the same response(s). But how does one apply this principle? The most obvious application is the ability to state whether something will pour. If something is member of the concept class "liquid," someone who has mastered the above principle could state that it will pour.

Principles can have multiple applications. Another way to demonstrate mastery is by stating that something is a liquid because it will pour, since the law of implication tells us that if the above statement, "If it is a liquid, then it will pour," is true, then the statement "It will pour OR it is not a liquid," also is true. What are some other ways to apply this principle? Well, suppose you are tasked with emptying spittoons[2]. Gross! How do you get that icky junk out of the spittoon? Is the icky junk a liquid? The icky junk is indeed a liquid. What do we know about liquids? We know that liquids pour. Given that, we can rephrase this principle to make it more useful. "IF it is a liquid, THEN it will pour," can be rephrased to say, "IF you want to dispose of a liquid, THEN pour it." Easy. But what if it is not a liquid? Suppose the spittle has frozen, forming a seemingly unextractable solid. Under these circumstances, we might rephrase the principle to say, "IF you want to pour something, THEN make it a liquid." How do you make turn frozen spittle into fluid spittle? You might try heating it up; solids typically change to liquid when you apply heat. Of course, that heat converts solids into liquids is a separate principle, and you would need to understand both in order to brew up some of that spittle-brew. What else would you need to know? To succeed here, you also would need to have a concept of (1) what a liquid is (2) what a solid is (3) what heat is. Some procedural knowledge of pouring and heating also is prerequisite.

[2] A spittoon is a large bowl, serving as a receptacle for spit, especially spit produced from chewing tobacco.

Let us attend to a second principle regarding principles, which is that not all of the information needed by the learner who is to apply the principle is explicitly stated within the principle. The principle says nothing of what "pour" is. Yet, we just determined that understanding the concept of "pour" is crucial. After all, the principle is really just saying how the concept of "liquid" is related to the concept of "pour." That relevant information is missing is perfectly all right, provided that the learner who is to apply the principle already has the concepts. Excluding information is an instructional decision that a designer can make according to the skill level of learners.

Necessary and Variable Conditions

Let's look at another example:

Scarce commodities command high prices.

What concepts are prerequisite to the application of the above principle? Is "scarce" a concept? What about "commodity"? The act of "commanding a price"? "High prices"? All of these concepts are essential to applying the principle. The principle says only how all of these concepts are related. If you do not have the concepts, the relationship between them is not useful information. Recall from the topic of concept learning that concepts have attributes, and that those attributes either are critical, meaning that altering that attribute results in a nonexample of the concept, or variable, meaning that altering that attribute results in a new example. Similarly, principles have necessary conditions and variable conditions. In the above example, a commodity's being scarce is a necessary condition because the principle applies only to commodities that are scarce. However, since the principle applies to all commodities, the type of commodity is a variable condition. The commodity could be a turkey or an XBOX or a share of Ford Motors.

What is a Strategy?

Knowing that a principle is a form of verbal behavior that acts as a discriminative stimulus for responding, we now can examine strategies. Like principles, strategies guide our responding. When we encounter a problem situation, we apply principles that, in the past, have worked in similar circumstances[3]. Strategies help us find these principles. When the principles we apply to the new situation do not meet success, we use strategies to search for principles that might meet success. Thus, a strategy is a set of principles that guide our selection and combination of principles and behaviors that we use to solve a new problem. To help understand what a strategy is, let's solve at a problem:

How many states begin with a letter that is not at the beginning of any other state's name?

Before hazarding a guess, ask yourself what form the answer will take. Will it be a list? A word? A series of letters? None of the above. The answer will be a number; the question asked "how many?" Determining the kind of answer is being looked for is a part of the strategy that goes into solving this problem. Another component of the strategy for this problem is determining whether you have the prerequisite knowledge. It is important to identify the areas of knowledge required to solve a strategy because to successfully solve a problem, you must be competent both in the general strategy you will use and in the prerequisite knowledge of the content-domain. To solve this problem, one must know (1) the sequence of numbers used in counting, (2) the sequence of letters in the alphabet, (3) the names of all the states in the U.S. and (4) their spelling. In this instance, the names and spellings may come to some of us more readily than others. The rest of us can look it up.

[3] That is, we apply principles that, in the past, have worked in problem situations that share salient attributes with the present situation.

Now go ahead and solve the problem on your own, and write down the steps you took to solve it, starting with looking up the list of states.

1. Looking up U.S. states.
2. Determine what the first letter of each state is.
3. Judging whether other states begin with the same letter.
4. Tallying the states that answer the question.
5. Stopping, upon reaching the last state.[4]

Features of Good Strategies

To be sure, there are other means of solving this problem. You could write out the entire alphabet and then match states to each letter and then count the number of letters matched only to one state. That would cover all possibilities, which is one feature of a good strategy. However, that would also be slow, and a feature of a good strategy is that it is efficient. Another feature of a good strategy is that a good strategy adapts to changes in the environment.

To illustrate the features of a good strategy, let us examine the game of hide-and-seek. In hide-and-seek, one player closes their eyes and counts aloud while the other players hide. When the first player has finished counting, he or she begins to search for the other players. For the player who is searching, starting in a room at one end of the building and moving systematically from room to room—checking every nook and cranny as they go through each room—are good strategies that we might call "being organized" and "being thorough". Those are good strategies because they cover all possible hiding places and because running from room to room at random is likely to be less efficient than a more organized approach.

But what if the kids who are hiding cheat by moving from a hiding spot that has not been checked to a hiding spot that already has been checked? Would this not cause the searcher's

[4] By the way, there are seven: Delaware, Florida, Georgia, Hawaii, Louisiana, Rhode Island and Utah.

strategy to backfire, since their strategy involves not looking in rooms that already have been searched? It would indeed. Cheaters! So here is where the adaptive feature of strategies becomes important. If the searcher plans to find those cheaters, his or her strategy needs to accommodate the change in rules. Any ideas? A first step to changing strategies might be specifying the changes in the environment. In this instance, the searcher might say, "The rules originally required me to locate people who are hiding in one spot, but now requires me to locate people who are changing spots." The next step is to determine whether the changes to the environment necessitate changes to the strategy. In hide-and-seek with cheaters, this might mean examining whether a room-to-room sweep still would cover all possibilities.

Minimal-Content Problems: Assessing the Use of Strategies

As mentioned above, successfully solving a problem using a strategy requires competence in (1) the general strategy you will use and (2) prerequisite knowledge of the content-domain, meaning you have to know the information required to solve the problem. Measuring peoples' competence in using strategies is complicated by the differences in peoples' knowledge of content-domains. Someone's failure to solve a problem may be the result of ineffective use of strategies, or a simple lack of relevant knowledge. Likewise, their success may be due to their effective use of strategies or an abundance of relevant knowledge.

This problem is far more pernicious than one might expect; the culture biases present in IQ tests are one example. One strategy for controlling the effects of relevant knowledge is the use of minimal-content problems. Put simply, minimal-content problems require general knowledge that the designer expects everyone to have. Knowledge of the basic counting system, of the alphabet, or the days of the week are examples of minimal-content. A popular example is the Bruner-Type Universe, which used simple drawings in place of words and facts.

Strategies of Various Sorts: "Means-Ends" Problems

A "means-ends" problem provides the solver with a starting point and describes the end that the solver must reach. The challenge for the solver is to find how to reach the end (the means). A classic example is the "river-crossing" problem, such as "You have a fox, a goose, and a bag of corn on one side of the river, one boat that will hold you and one other, and you have to get yourself and all of them to the other side. If you leave the goose with the corn, the goose will eat it. If you leave the goose with the fox, the fox will eat the goose." A useful strategy described by the literature is working backwards from the end: determine the state you ought to be in when you are ready to make the final moves to finish the task. In this example, the last move is performed you are crossing the river carrying one thing while two things wait across the river. The things across the river must not eat each other. Only one combination of two items, fox/corn, will not eat each other. The fox and the corn are across the river. The goose is in the boat. If you made three crossings, then none of the ways that the goose could be last would result in nothing being eaten. So, you must have made more than three crossings, which means you must have crossed with something twice, which means you must have brought something back across the river. Since the goose is the last item in the boat, it must have been the goose that you brought back across the river. And so on.

Arrangement Problem

An arrangement problem requires you to make sense of a set of givens. An example is word jumbles. Working backwards is of no help, because you are unaware of what the end looks like. After all, it is that end that you are trying to determine. Strategies offered by the literature are perhaps unsatisfying, saying to "proceed in some organized fashion" and "make sure you cover all possibilities." By "organized fashion" is meant some strategy that the solver believes will lead to a solution in less time. For example, in the case of word jumbles, rearranging vowel-consonant

combinations may cover all possible combinations and lead to success faster than writing out each possible permutation, because the structure of language restricts the placement of vowels.

Rule-Finding

Rule-Finding problems frequently appear in intelligence and aptitude tests in the form of verbal and figural analogies, matrices, and serial problems. These exercises require the solver to examine a set of stimuli and state the rule that relates them. Often, these problems require the solver to select a stimulus that is related to the sample stimuli in the way specified by the rule, as is the case in analogy problems. The literature discusses two strategies for solving rule-finding problems, “conservative focusing” and “hypothesis testing”, both of which are similar in that they guide your responding so that it covers all possibilities in an organized fashion. Conservative focusing requires you to hold all attributes constant except the variable that you are testing. Thus, when that attribute is present in a nonexample, you know that it is a variable attribute. Hypothesis testing requires the solver to inspect a target example for dimensions, pick a target hypothesis of 1 to N dimensions, go through the universe of examples until you find an item in which every other dimension has changed and test it, and continue with this procedure until they have arrived at the answer.