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ABSTRACT

The instructional design presented in this article discusses a procedure for arranging and sequencing examples and nonexamples for concept teaching in the classroom. Concepts are divided into two types: definition and observation. A definition concept is one in which the critical attributes are determined by the definition, e.g., war. Observation characteristics have measurable or observable physical characteristics. Characteristics of a concept are either relevant (i.e., basic), or irrelevant. Discrimination between concept classes can be illustrated by use of a Venn diagram. Examples of concepts and concept classes are either convergent (their irrelevant attributes are as similar as possible) or divergent (their irrelevant attributes are as different as possible). The most effective relationship between examples and nonexamples of a concept is matched: that is, an example and a nonexample have similar irrelevant attributes. In that case, the only difference between them is the critical attributes of the concept. Examples of concepts can also be discriminated between on the grounds of whether they are easy or hard. (JK)

CAI CENTER

TECH MEMO

METHODOLOGY FOR THE SEQUENCING OF INSTANCES IN CLASSROOM CONCEPT TEACHING

Robert D. Tennyson
and
Richard C. Boutwell

Tech Memo No. 76
January 30, 1973

Center for CAIR
The Florida State University
Tallahassee, Florida 32306

FLORIDA STATE UNIVERSITY

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Methodology for the Sequencing of Instances in Classroom Concept Teaching

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Recent instructional research studies (Tennyson, Woolley, & Merrill, 1972; Merrill & Tennyson, 1973a, 1973b; Tennyson, 1973) have investigated variables and conditions that have a direct application to the design of concept teaching. The procedures for the sequencing of examples and nonexamples reported in this article are based on an empirically-validated instructional design theory, which addresses itself to classroom application rather than the raw empiricism "laboratory" approach. The premises of the raw empiricism developmental procedure are that instructional outcomes should be specified, learner performance should be observed, and the instructional process should be revised until performance corresponds to the specified outcomes. The result is that the tryout-revise cycle must be repeated many times, thus inflating the cost of instructional development and delaying attainment of optimal performance levels or instructional efficiency.

Oftentimes the immediacy of the classroom instructional setting is lost to the researcher in the laboratory. The pragmatic and unnecessarily crude decision-making of instructional variables which takes place in classrooms could be avoided if research implication would be disseminated to enhance greater use rather than to solidify existing barriers between

classroom and laboratory. In reviewing Clark's (1971) article which cited over 200 studies dealing with concept acquisition, it was found that less than ten percent of the articles cited included concepts which would commonly have been associated with the classroom environment This lack of real-world concern on the part of recent concept learning research has resulted in an equal lack of implementation of instructionally superior methodology.

Another problem for classroom teachers, vis-a-vis research findings, is that research investigators frequently have not made a distinction between various kinds of instructional outcomes, and have tended to investigate simple tasks and then generalize their findings to all learning situations. In addition, most of those laboratory experiments deal with simple recall tasks rather than on the more desired classroom behaviors of concept learning, rule using, and problem solving. Merrill and Boutwell (1973) surveyed previous reviews of research literature related to instructional psychology (Anderson, 1967; Gagné and Rohwer, 1969; and Glaser and Resnick, 1972) and found most of the reported experimental studies to be concerned with the cognitive ability of recall information The purpose of this article will be to investigate the higher cognitive skill of classification (concept acquisition), and its implication for direct application on the part of the classroom teacher.

Mechner (1965) defined concept acquisition as generalization within a class and discrimination between classes. He pointed out that unless both processes were assessed simultaneously, it was not possible to infer concept acquisition. In order to assess concept acquisition, both examples and nonexamples must be presented to the learner, and his

ability to generalize to new examples and discriminate them from nonexamples is observed. Markle and Tiemann (1969) and Merrill (1971) postulated adequate concept acquisition would result only if examples used during instruction clustered in the irrelevant attributes associated with each; this promotes generalization within the class. Discrimination between classes results from presenting nonexamples which have irrelevant attributes resembling those with given examples. Markle and Tiemann (1.c., also postulated that unless the above conditions were met, certain classification behavior errors would result. These are overgeneralization, undergeneralization, and misconception.

Classroom Application

The term concept means to employ the complex cognitive level of behavior (cf. Gagné, 1970; Merrill, 1971). A concept is a class of objects or ideas which are characterized by the same critical attributes. There are two types of concepts: definition and observation. A definition concept is one in which the critical attributes are determined by the definition. This type includes nationalism, love, war, happiness, friendship, etc. Observation concepts have measurable or observable physical characteristics. This type is concerned with trees, chairs, books, parents, etc.

An observation concept: A chipmunk is of the genus Tamias, of the squirrel family.

This concept deals with a subject (chipmunk) that has observable physical characteristics. The observation concepts are generally easier to teach since their limits are definite; for example, it is easier to describe a chipmunk than to describe fear.

A definition concept: Fear is the painful emotion aroused when apprehending evil or harm.

In this instance, the limits are set by the definition. If the definition was expanded, the word would assume additional meaning. For example, the word had this obsolete addition: Fear is respectful reverence for men of authority or worth. That broadening of the definition would change the entire concept. So definition concepts are somewhat subjective, and observation concepts tend to be objective.

When teaching concepts the definition can be clarified by giving for the student the component elements of the concept. For example: A fang is a long, sharp tooth. This regular definition can be extended to be an attribute definition by explaining the component parts, that is, long, sharp, and tooth. Thus the attribute definition would begin:

> A fang is a bony appendage protruding from the jaw, of a greater length than the standard, and having a fine point designed to cut or pierce easily.

There are irrelevant attributes of a definition. These are the aspects that are not basic to the meaning. However, irrelevant attributes often add superfluous information that can help the student understand the concept. Refer to the observation concept chipmunk. Irrelevant attributes may include the following information:

1. The chipmunk is terrestrial in habits.
2. It is often called a ground squirrel.
3. In the west there are numerous species.
4. Most chipmunks are brown.

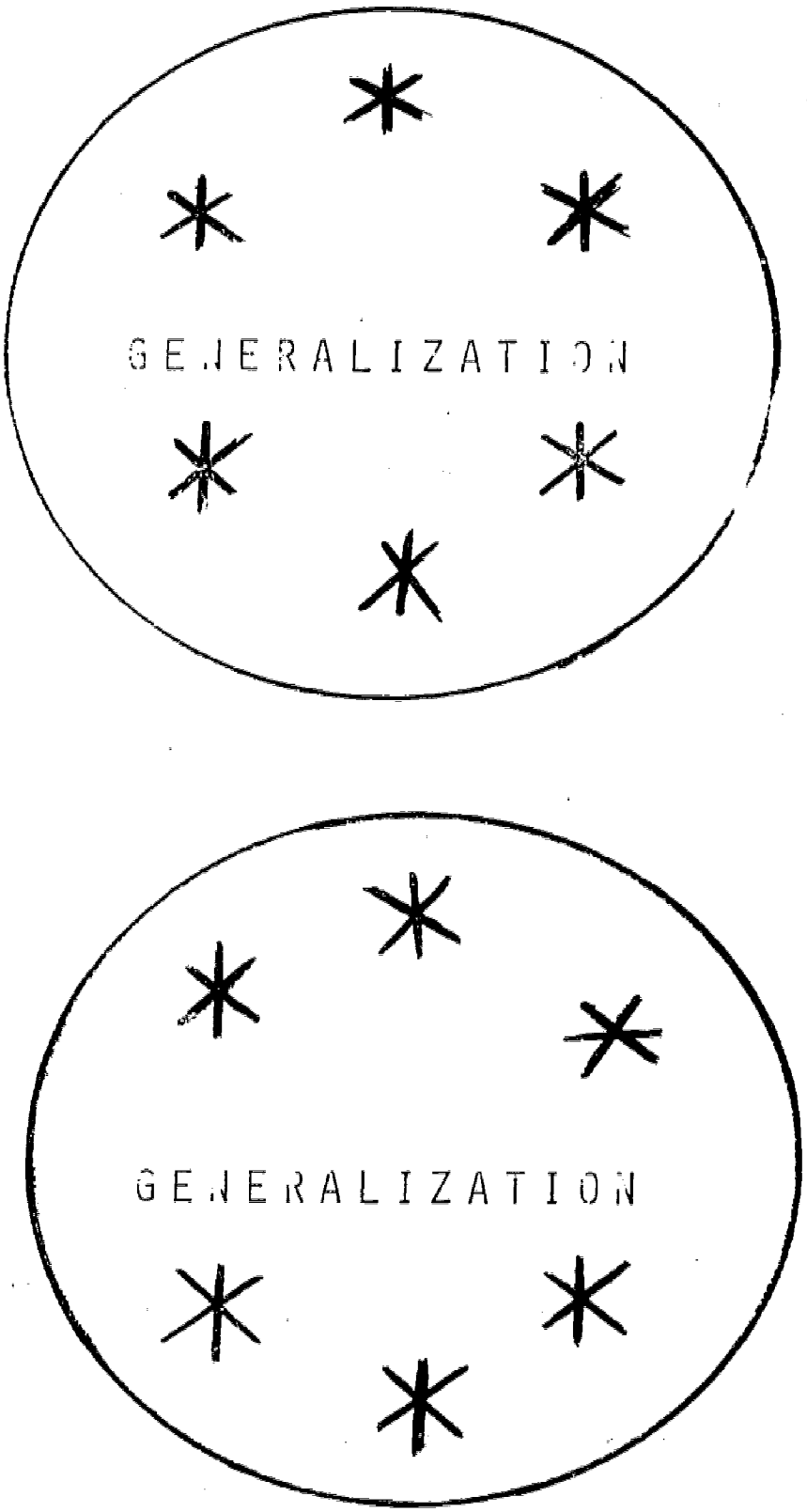
None of the four irrelevant attributes listed above places the chipmunk into the concept class chipmunk. Extremely elementary irrelevant attributes would include such items as:

1. Chipmunks have two eyes.
2. They each have a tail.
3. Their bodies are fur-covered.
4. They seem nervous.

Again, none of the above attributes apply only to chipmunks. However, these irrelevant attributes would help give a 5-year-old the correct concept of a chipmunk.

Generalization within a concept class can be illustrated by a Venn diagram (Figure 1). Each * indicates one example within the concept class. For the best teaching, only a part of those examples will be used to represent the whole class. The student will be tested with unencountered examples to see if he can generalize beyond the "spoon-fed" examples. Suppose each * represented a pronoun and the circle included all pronouns. The teacher would present the definition (critical attributes), and then select examples that helped the student understand the entire class. The teacher may say, "He is an example of a pronoun. It can represent a name. Is she a pronoun?" If the student was able to identify she as another example, then the student has generalized to other pronouns.

CONCEPT ACQUISITION



DISCRIMINATION

FIGURE 1. VENN DIAGRAM

Discrimination between concept classes can be illustrated in the same manner (Figure 1). Each * within the class indicates one example of that concept class. The two circles represent nonexamples of the concept class being taught. When teaching a concept class, it is not only desirable that a student be able to generalize within the class, but he should be able to discriminate the members of the concept class from nonmembers of the class. For the concept of the pronoun, the teacher will want the student to recognize all pronouns encountered (generalize), and be able to recognize other parts of speech as not being pronouns (discriminate). So if the teacher asks, "is flower a pronoun?", the student will respond that flower is not a pronoun. He has then discriminated between concept classes

Examples are either convergent or divergent (Tennyson et al., 1972). Two examples are convergent when their irrelevant attributes are as similar as possible. For example, here are two selections of poetry. (The critical attribute is that they are examples of the same concept class.)

#1 Maid of Athens, 'ere we part,
Give, oh give me back my heart!
(Byron)

#2 Sure solacer of human cares
And sweeter hope, when hope despairs!
(Bronte)

Some irrelevant attributes are: they were written by Romantic poets, the lines each have four measures, each is an exclamation directed to

a single individual, etc. But none of these irrelevant attributes is responsible for the example being of the concept class poetry.

Examples are divergent when their irrelevant attributes are as different as possible. Here are two more selections from the concept class poetry:

Out of childhood into manhood
Now had grown my Hiawatha.

(Longfellow)

The God of love my shepherd is,
And He that doth me feed.
While He is Mine, and I am His,
What can I want or need?

(Herbert)

Inspection reveals that these examples diverge in the following aspects: they are of different length, the poets represent different time periods, the subjects have no relationship, etc.

The most effective relationship between examples and nonexamples is matched (Tennyson, et. al., 1972). A matched situation occurs when an example and a nonexample have similar irrelevant attributes. The only difference being the critical attributes. Using the poetry illustration again, suppose the concept to be taught was trochaic meter. The critical attribute is the meter: a stressed syllable followed by an unstressed one.

All other things would be irrelevant as in the illustrations above.

Concept sets Effective concept teaching not only employs examples and nonexamples, but employs matched sets and divergent sets. The most efficient organization of examples and nonexamples is in a "concept set." A concept set consists of two divergent examples, each matched to a nonexample, with prompting of the critical attributes. Prompting is a term which means identifying the critical attributes by various devices, such as verbal descriptions, diagrams, arrows, etc. This helps to focus the student's attention on the attributes which define the concept class. A third necessary component of a concept set is the equal difficulty of the instances, i.e., some examples are easier to recognize than other examples, thus, the harder the example the more difficult it would be to identify by the student. Obtaining a measure of instance difficulty is a two-step function known as an instance probability analysis. A complete description of this process is found in an article by Tennyson and Boutwell (1973).

An example of a concept set is the following:

Definition: Mutualism is a phenomenon in nature in which two associated organisms derive benefit from living together.

Critical attributes: Size; type of benefit;

CONCEPT SET #1

Attribute Prompting:

Example: Tickbird and Rhinoceros. The tickbird eats lice off the rhino (his main source of food), and in turn the tickbird warns the rhino of approaching animals. (Both benefit.)

Not an example - Fleas on a dog. The fleas live on the blood of the dog, and are a hinderance to him. (Parasitism.)

Example: Hermit Crabs and Sea Anemones. The sea anemone settles on an old shell inhabited by the crab. Other predators won't attack the crab because of poison tentacles, and in turn the crab moves the anemone around. (Dispersal.)

Not an example - Small fish and Sea Cucumber. The small fish lives in the cloaca of the sea cucumber (protection and dispersal) while hindering the cucumber.

The two examples are divergent because one uses land organisms while the other uses sea organisms. The two instances have the defined critical attributes, but the student will see that mutualism exist on both land and sea. Two quite different types of benefits are demonstrated. The first matched a much larger one, however, one is beneficial, while the other is not. In the second matched condition two organisms attach themselves to another, but the nonexample shows a parasitic condition. The prompting is in the form of a verbal description of the relationship between the two organisms. The difficulty level of the instances is easy i.e., the two examples are easily recognized as members of the concept mutualism, and the two nonexamples are easily recognized as nonmembers of the concept. Usually, one concept set is insufficient for learning, therefore, a range of difficulty of sets is required. The succeeding sets

should be as different as possible from the first, and so forth. In other words, the individual concept sets are divergent. The complexity of the concept determines the final number of concept sets to include in the total instructional program. A concept set divergent to the first is the following:

CONCEPT SET #2

Example: Termite and Flagellate Protozoa. The protozoa find a place to live in the stomach of the termite, and provide the enzyme for the termite to digest wood. (Both benefit.)

Not an example - Tapeworm and man. The tapeworm lives in the adult stage as a parasite in the intestines of man.

Example: Algae and Fungus. The algae produce food for the fungus and the fungus holds water that the algae use to make food. (Both benefit.)

Not an example - Dodder on plants. The dodder sucks nourishment from the host plant.

The instances used in this concept set are somewhat harder than in the previous set. Again the two examples are divergent; one an organism that lives in wood, while the second in any place where moisture is available. The nonexamples show the matched relationship with examples. Notice that the prompting focuses the student's attention on the critical attributes.

Designing instruction is unique for each content area. We emphasize that the steps presented here can and should be modified to

your own objectives. The following example of a concept set on geometric figures will illustrate this point:

Concept definition: A square is a plane figure having four equal sides and four right angles.

Critical attributes. A plane is a surface that wholly contains every straight line joining any two points lying in it. A figure is an outline or shape of something, form. Equal means of the same quantity, size, number, value, degree, intensity, etc. Angles are the shape made by two straight lines meeting at a point, or by two plane surfaces meeting at a point, or by two plane surfaces meeting along a line.

Irrelevant attributes: Size; shape; ability to stand alone.

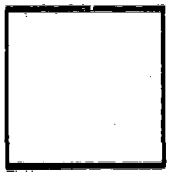
Example 

A. each is small

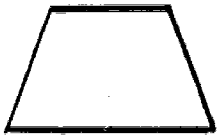
Nonexample

B. each has four sides

C. each has a base line

Example 

A. each is large

Nonexample 

B. each has equal length sides

C. each has four sides

Notice that the definition is similar to our past examples, but the critical attributes are written in phrases, rather than in short statements, while the irrelevant attributes are short statements. Your style and approach to the subject matter is different from other teachers, and how you implement the steps in instructional design will be unique. The above concept set uses another modification in that the

prompting stresses the similarity between the matched instances; the student has to then infer the critical attributes.

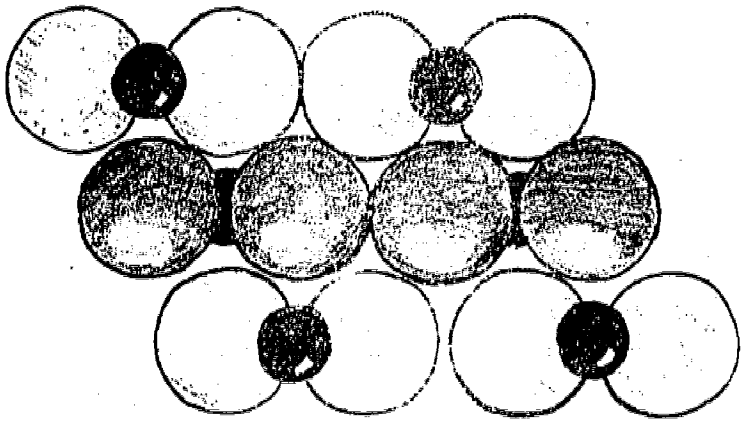
Another example of a concept set is the following on crystals. In this illustration the prompting is detailed because of the complexity of the concept, and that the grade level is college, which requires more detailed content than the simple example on squares.

Concept definition: there is a type of crystal called RX_2, which has two-to-one ratio in its atomic structure, i.e., for a given atom there will be another two (on cluster of atoms) attached to it in a repeating fashion.

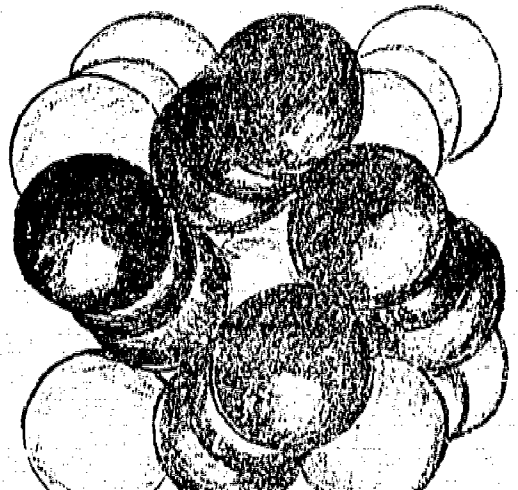
Critical attribute: two-to-one ratio

Irrelevant attributes: size, color, density, shading

Example:



Example:



In identifying crustal types from these pictures, different atom types can be denoted by different:

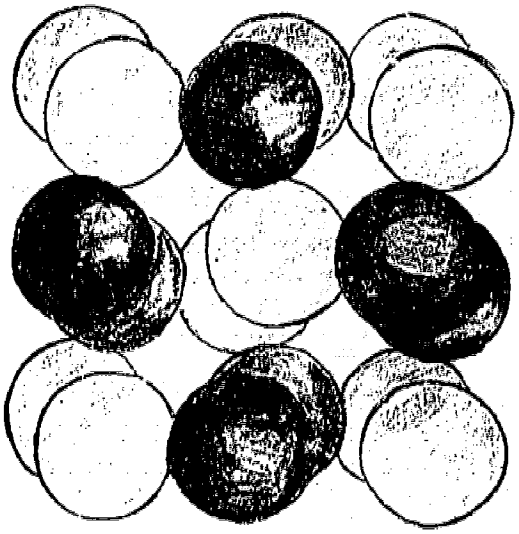
1. sizes; 2. types of shading (amount of shading shows depth);
3. colors (black & white)

or some combination of these three properties.

In this example, type of shading and color are properties not used to differentiate the atom types.

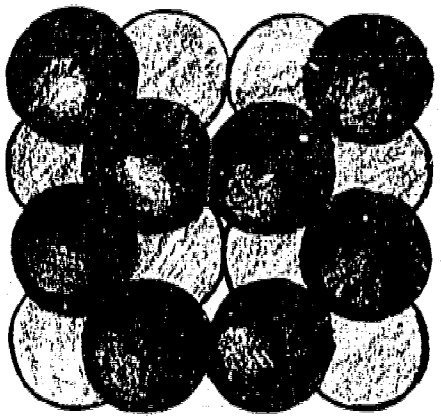
This example points out subtle features which help in example identification. First, the different sizes of atoms is necessary for differentiation of atom types. Second, the amount of shading (for depth) draws your attention to the basic cluster.

Not an Example:



The crystal shown below is a nonexample because it contains only one type of atom, i.e., the atoms have the same size, same color, and same type of shading.

Example:



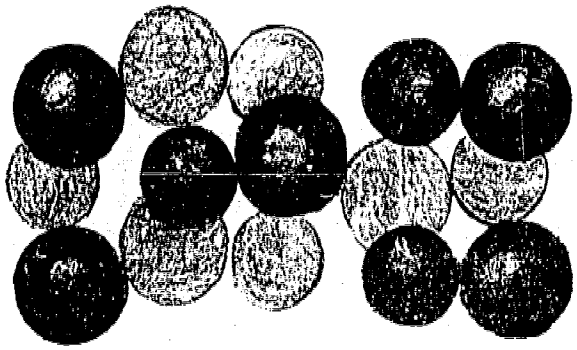
In identifying crystal types from these pictures, different atom types can be denoted by different:

1. sizes; 2. types of shading (amount of shading shows depth);
3. colors (black & white)

or some combination of these three properties.

In this example, size and color are not used to differentiate the atom types. The characteristic that makes the two atom types different is their internal markings (type of shading). One has short lines rather than dots for shading. Once you have discovered both types, all you must do is discover the ratio.

Not an example:



This nonexample has the atom types characterized by both different sizes and different internal markings. The ratio of these two types is one-to-one.

The above instances were selected from a larger group which had been rated in an instance probability analysis (see Tennyson & Boutwell, 1973). The level of difficulty for the four instances was easy. We will not show another concept set on RX_2 crystals, but remember that several concept sets are necessary.

In the previous article (Tennyson & Boutwell, 1973) we presented the procedures for conducting an instance probability analysis using, as an example, the concept of adverbs. The article ended with a group of sentences identified as easy and a second group as hard. The next step was to take those instances and arrange them into concept sets. Below are the instructional choices organized into an easy and hard concept set (refer to the other article for ratings).

Easy Concept Set:

Example: Slowly, she walked home.

Slowly tells how. Slow describes the girl, so it is an adjective. It does not affect the verb.

Nonexample: She is slow.

Example: Are you fighting mad?

Mad is an adjective, f[illegible] tells to what extent. Do fight is the verb; do is a helper needing another verb to complete it.

Nonexample: Do you fight?

Hard Concept Set:

Example: The small floral print looked pretty.

Small modifies floral (an adj.).

Nonexample: The small print looked pretty.

Small modifies pattern (a noun).

Example: The most dangerous weapon is a gun.

Most tells to what extent the gun is dangerous.

Nonexample: Most guns are dangerous.

Most qualifies the noun.

The number of concept sets depends on the difficulty of the concept class. You, as the teacher, have to make that decision.

Conclusion

The instructional design presented in this article discussed a procedure for arranging and sequencing examples and nonexamples for concept teaching in the classroom. Whether the user be a teacher or instructional developer, the methodology is adaptable to the individual's own objecti... We recognize that different subject matter would require modifications of the system, however, the basic format does generalize across content. With continued practice you should develop unique variations that will improve the concept set to your instructional needs.

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