Learning Abstract Concepts: The Use of Analogies as a Mediational Strategy

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Abstract. This paper examines the differences between concrete and abstract concepts and the implications of those differences for instructional design and teaching. The use of analogies is suggested as an instructional tool in abstract concept learning. Using the published literature on concept learning and analogies, the authors examine how specific concepts are stored in and retrieved from memory, the particular problems presented in learning abstract concepts, and how analogies mediate between the vague, intangible attributes of abstract concepts and those of a more concrete nature. Finally, they present a possible instructional strategy for teaching abstract concepts.

Categorization is a powerful tool used by humans of all ages to organize and simplify the complex world (Glass & Holyoak, 1985). For example, the following are common classification tasks:

1. Given pictures of several previously unencountered animals, a child selects only those photographs of cats.

2. Presented with a number of stone tools, an archaeologist categorizes those that are Acheulian hand axes.

Efficient and effective methods of learning such skills, as suggested by Merrill and Tennyson (1977) and others (e.g., Dodd & White, 1980; Gagne, 1985), require within the classification process a step that compares the common properties exhibited by members of the concept with those of the to-be-classified items. In other words, classification requires, first, identifying the perceptual, functional and/or relational properties or attributes required of all concept members, and, second, contrasting those with the attributes of the newly encountered item. A match between relevant attributes determines if the item is or is not to be included within the category.

A problem with such learning develops, however, as concepts with vague, intangible, or imperceptible attributes are encountered. For example:

3. Presented with short vignettes describing life in several previously unencountered societies, the political science student lists those societies that represent democracies.

4. During a field trip to an art museum, grade school children are asked to point to all objects that represent beauty.

Though examples 3 and 4 require classification skills similar to those of examples 1 and 2, neither concept, democracy nor beauty, possesses perceptible attributes. As a result, the difficulty of classification is increased (Reed & Dick, 1968). Many natural classifications are based on such abstract concepts; however, little research has been conducted to suggest how they are initially learned or incorporated within memory (Glass & Holyoak, 1985).

The present paper addresses the following basic question, "Do the differences between abstract and concrete concepts involve totally different learning processes and thus, mandate different instructional strategies?" The subsequent answer involves several parts. First, the manner in which specific concepts are stored in and retrieved from memory is examined. Second, the problems presented by abstract concepts and their imperceptible attributes are identified. Third, a way to mediate between the vague attributes of abstract concepts and those of a more concrete nature is introduced. Finally, a prescription illustrating a possible instructional strategy is suggested.

Concept Acquisition and Use

Concepts have been defined as particular sets of objects, events, symbols, properties, or situations that can be grouped together on the basis of one or more shared characteristics and are given a common identifying label or symbol (Ausubel, Novak, & Hanesian, 1978; Merrill & Tennyson, 1977). Once acquired, concepts provide learners with the capacity to classify items based on the existence of certain essential characteristics, features, or attributes (Klauser, Chatala, & Frayer, 1974). For example, a triangle is a two-dimensional enclosed geometric figure having three sides. To be so classified, a given item must be two-dimensional, enclosed, and three sided. Other attributes, such as size, color, and spatial position may or may not exist in a particular triangle and, thus, are irrelevant to its classification.

The classical view of concept acquisition is based, in part, on the early research of Bruner, Goodnow, and Austin (1955). It assumes that the instances of a concept share a specific set of common attributes or features. Moreover, these features are necessary and sufficient to define the concept (Medin & Smith, 1984). During a classification task subjects match the presented stimuli with the required attribute list according to a simple comparison rule (Millward, 1980; Tennyson, Chao & Youngers, 1981). For example, learning the concept chair, under this view, would require focusing the instructional strategies on the concept's critical attributes (i.e., a seat, legs, for one person, etc.) and on the encoding of the list of attributes within memory.

Given a room full of items with the task of identifying a chair, the learner would then be required to retrieve from
memory the concept’s associated critical attributes and match those with the presented items.

As outlined by Medin and Smith (1984) this view has several inherent problems, including the failure in many cases to specify a concept’s list of defining attributes, dealing with unclear category boundaries, and explaining the unequal status (i.e., some instances appear more typical than others) of category members (Battig & Montague, 1969; Rosch, 1978).

One alternative hypothesis deals with the learning of prototypes. A prototype, as explained by Tennyson and Cocciarella (1986), “is like an image (abstraction) of the average, or typical, category member. People, therefore, learn and remember concepts as contextual entities (correlational structures), with common attributes that are the most typical, or average, members of a class.” According to this assumption, prototypes are not a specific instance or item, but are formed by combining a collection of instances into a single representation of the concept. During classification, the prototype is recalled and compared with the to-be-classified item. A sufficient degree of similarity between the prototype and its inherent attributes with those of the new item determines if the item is included within the concept (Glass & Holyoak, 1985). For example, acquisition of the concept chair, under the prototypic hypothesis, requires the learner to use his/her past experience to form a single image that encompasses the majority of the appropriate attributes. Correct classification of new items is the result of recalling the prototype with its associated attributes and comparing it with the attributes of the new item. If the new item has a sufficient degree of similarity to the prototypic chair (i.e., the attributes of the prototype and that of the new item closely match), it will be judged to be a member of the chair category.

The essential difference between the two methods involves the way these attributes are stored in memory. This difference is represented in Figure 1. The classical view postulates that it is the listing of attributes that is stored in memory. At recall, the list is retrieved from memory and used to compare with the new instance. (Glass & Holyoak, 1985; Medin & Smith, 1984).

In a direct test of the prototype versus classical views, Tennyson, Youngers, and Suebsonghi (1983) presented groups of third-grade math students with a concept definition followed by either a best example or a list of attributes. Classification tests conducted immediately after learning and then again two weeks later showed that subjects trained with the best example scored significantly higher than the attribute-list group. Additionally, reaction time experiments have shown that the more typical an instance is of a category, the more similar it is to the category’s central tendency prototype, the more quickly and easily it can be classified (Rips, Shoben & Smith, 1972; Rosch, 1973). Additionally, Shepp (1978) found evidence that children learn concepts primarily from clear cases or best examples and then later come to recognize the similarity between a new example and a known example.

**Abstract Concepts**

To date, most research has been concerned with concepts that have perceptible, concrete, or easily definable attributes (Glass & Holyoak, 1985).
However, as shown by the investigations of Reed and Dick (1968), many concepts possess different degrees of abstract, imperceptible, and difficult to define features. Bird, tree, and river, for example, possess attributes that have been found to be easily formed into a prototype. Justice, emotion, and travel, on the other hand, contain attributes that are more abstract and far less perceptible. From such examples, it is easy to see that concepts can be defined along a continuum according to their concreteness or abstractness. Those at the abstract end of the continuum are qualitatively different than their concrete counterparts in several ways that have important implications for the manner in which they are taught and learned.

Abstract concepts differ from concrete concepts along three dimensions: membership, tangibility, and complexity. Membership criteria refers to the clarity of the concept's definition and the criteria which distinguish members from non-members. The definition of an abstract concept depends on the context in which it occurs and there is a "gradient of typical to atypical members" (Cohen, 1983). Membership, therefore, can be ambiguous. Membership in a concrete concept category is likely to be less ambiguous.

Tangibility refers to the degree to which the concept can be defined perceptually. Neither the attributes nor the exemplars of an abstract concept can be perceived directly. As a result, only an indirect definition is possible, using a symbol system such as language.

Complexity refers to the degree to which understanding the concept is related to understanding other concepts. Abstract concepts "rest in a substrate of underlying concepts" that must be understood in order to learn the new concept (Cohen, 1983).

These qualitative differences are represented in Figure 2. The question then becomes "How is this type of concept most effectively and efficiently learned?"

Abstract concepts present a particular problem for instructional design and teaching. Concrete concepts like chair are generally unambiguous and tangible. Their attributes are usually easy to identify and to encompass within a single prototype. Abstract concepts, on the other hand, are not easily represented within a single prototype. Membership in an abstract category can be ambiguous. The more abstract the concept the more difficult it will be to find instances that will be widely accepted as "clear cases." There is likely to be disagreement about an abstract concept such as art. An impressionistic painting may be considered art by some and a mere splash of color by others; a photograph in an album may be considered a keepsake while the same photograph, enlarged and mounted on the wall, may be considered art. In addition, abstract concepts cannot be defined perceptually because their attributes are intangible. Justice cannot be seen, heard, felt, tasted, or smelled as can chair.

Prototypes are produced from a collection of specific clear instances, using the attributes of the concept. A concrete concept generally has tangible attributes and clear instances allowing the learner to generate a prototype to represent it. With an abstract concept, however, there are no tangible attributes and the instances of the concept are not as clear-cut. As a result, it is more difficult for the learner to produce an effective prototype. As Reed and Dick (1968) point out, this makes learning an abstract concept more difficult and time-consuming.

Referring back to Figure 1, it can be seen that removing the prototype from the learning process leaves only the classical view of concept acquisition. Using this method involves the delineation of a list of attributes to use as a comparison with a new item. This is simple enough with concrete concepts because their attributes are generally tangible and easy to identify. The attributes of abstract concepts, however, are likely to be abstract concepts themselves, each with a set of defining attributes to be learned. For example, learning the concept justice involves understanding the concept impartiality, which involves understanding the concept bias, and so
An analogy facilitates abstract concept learning by helping the learners generate a prototype substitute for the concept.
concrete, familiar image that encompasses salient defining attributes and that can be used as a prototype substitute for the concept *justice*.

Given the task of applying the new concept in a specified situation, the learner reconstructs the concept's attributes by first recalling the analogy connecting *justice* to the concrete image of a *scale*. Recalling that the analogy establishes an "is like" relationship leads the learner to recall how *justice* is like a *scale*. This leads, in turn, to further recall of what is known about *justice*. This recall process continues until the learner has recalled enough of the attributes of *justice* to apply to the new situation. If there is a close enough match, the new situation can be classified as an example of *justice*.

**Prescriptions for Use of Analogies**

Effective analogies are neither randomly nor arbitrarily constructed or used. Analogies, as a technique to facilitate learning, will be most effective when they are systematically designed and used. The following prescriptions are suggested by the authors as a way to present a sequence of activities using analogies as an instructional strategy to facilitate learning an abstract concept.

**Decide Whether to Use an Analogy**

Although they can be used with any content or group of learners, analogies are most useful when the information to be learned is not readily grasped by the learner. When the learner readily comprehends the content, analogies are superfluous. They add to the study time involved in learning the content (Simons, 1984) and may not warrant the additional investment of time. When the content is not easily understood, because it is abstract, complex, difficult, or outside the learner's experience, analogies are useful because they describe the new content in terms of other information that is simpler or more familiar. For example, likening red blood cells to trucks will be a useful analogy with elementary school students encountering the circulatory system for the first time. It will be unnecessary for medical school students who are already well versed in the functions of red blood cells.

**Construct the Analogy**

Several steps are involved. The first step is to identify one or more attributes of the concept that are particularly salient for understanding it. These attributes will be highlighted by the analogy. For example, constructing an analogy for the concept *justice* begins by identifying the weighing of two sides and balancing them as especially relevant to understanding the concept as a whole.

The second step is to find something from the learner's prior experience having the same or similar attributes. The thing selected should be concrete and familiar. The value of an analogy in teaching an abstract concept is that it "concretizes" the abstract information contained within the concept by comparing it to something tangible (Simons, 1984). For example, likening *justice* to a *scale* will work better than likening it to *democracy*. Both comparisons may be accurate, but a *scale* has tangible characteristics that can more easily be encoded into memory and used to provide a framework for understanding information about *justice*. Comparing the new concept to a familiar item helps bridge the gap between what the learner already knows and the new concept. An unfamiliar item would need to be explained to the learner before an analogy containing it could be used effectively and this additional explanation time would reduce the efficiency of the instruction. For example, likening *justice* to a *scale* will be effective to the extent that the learner is familiar with scales and their balancing characteristics. Without this knowledge it would be necessary to explain what a *scale* is and what it does before it could be used as an analogue for *justice*.

The third step is to thoroughly and clearly describe the resemblance or similarities between the two things compared in the analogy. This "is like" relationship is the primary means through which the analogy exerts its instructional power (Rumelhart & Norman, 1981). It establishes the link between the new concept and some existing knowledge, and it provides the basis for the recollection of what is known about the concept. Learners who do not clearly
and thoroughly understand the nature of the "is like" relationship in the analogy may develop only a limited understanding of the new concept. They may not be able to apply the concept in a range of specific situations. For example, likening justice to a scale based solely on the fact that it involves two sides gives the learner information that is necessary and accurate, but insufficient for fully understanding the essential nature of justice. The learner's knowledge will be incomplete and he/she may not be able to correctly apply the concept in the wide range of situations in which it appears.

According to Curtis and Reigeluth (1984), the power of an analogy can be strengthened by identifying its boundaries or limitations. Including the differences as well as the similarities between the things compared in the analogy increases the amount of information available to the learners. For example, justice is not exactly like a scale. Justice involves balancing the opinions or wishes of two people while a scale balances the weights of physical objects. Describing this difference along with the analogy may help the learner better understand the concept justice. An analogy should be kept simple, however. Including more information or explanation than the learner can easily assimilate with the analogy may be confusing and require extra learning time.

Properly constructed, an analogy has several benefits in abstract concept learning. First, it focuses the learner's attention on attributes considered particularly relevant to understanding the concept. To learn a concept the learner must discriminate between defining and irrelevant attributes. An analogy helps him/her sift through the extensive information encompassed by an abstract concept and focus on the attributes that will be most useful in comprehension and retention (weighing and balancing two sides, for example). Second, an analogy synthesizes a number of the concept's attributes into a single, familiar "concrete associate" (Alesandrini, 1982; 1984). An analogy picks out a small number of particularly salient attributes from the expansive array associated with an abstract concept and blends them together to form a single image (a scale, for example). This image is easier to encode into memory because it can be processed as a single entity rather than as a collection of parts and because it can be incorporated into some existing knowledge. Finally, an analogy provides an elaborative cue for the recollection of what is known about the concept. The process of remembering a concept is reconstructive. Starting with a small bit of information, details, examples, and inferences are gradually added until a network of interconnected ideas and information has been constructed (Anderson, 1980). Once begun, the process is self-generating. As specific details are recalled, they trigger the recollection of additional information until the desired level of detail has been reached. Using an analogy initiates this process by providing a memorable image along with a few associated pieces of information. For example, recalling how justice and a scale are alike triggers the recall of additional pieces of information until enough has been recalled about justice to apply the concept in a given situation.

Decide on a Presentation Format for the Analogy

An analogy can be presented in a verbal, pictorial or combination verbal-pictorial format (Curtis & Reigeluth, 1984). For example, an analogy for the concept justice can be presented verbally, "justice is like a scale;" pictorially, using a picture of a scale labelled justice; or in a combination format. The combination format may provide the strongest presentation because each form of the analogy will reinforce the other.

Present the Analogy Early in the Instructional Sequence

As described earlier, analogies work as new information is taken in, helping the learner interpret the new information and transform it into a prototype substitute that will be retained in memory. (This is similar to the function of "subsuming ideas" described by Ausubel, et al., 1978). To be available, as a new concept is taken in and encoded, an analogy should be presented during the initial stage of the instruction, along with, or immediately after the concept definition. For example, likening justice to a scale along with the concept definition makes the knowledge the learner has acquired about scales available to use as a subsuming framework as information about justice is taken in and encoded.

Relate Presented Examples and Non-examples to the Analogy

Once it has been defined, a concept is instantiated by presenting a series of identified examples and non-examples (Merrill & Tennyson, 1977; Tennyson & Cocchiarella, 1986). When an analogy has been presented with the concept definition it can be used as a comparison for each instance to demonstrate how it does or does not fit the concept category.

Use the Analogy in the Provision of Corrective Feedback During Practice

Practice involves the opportunity to use the newly learned concept in specific classification tasks. Corrective feedback refers to reinforcing correct classifications and helping the learner pinpoint the errors in his/her incorrect classifications. Referring back to the analogy offers the learner a way to check the correctness of his/her classifications. The learner can be reminded of the analogy and/or asked how the concept and its analogue are alike as a way of helping him/her discover how his/her incorrect classifications are incorrect and how they can be rectified. For example, when practicing applying the concept justice, the learner may be reminded of the analogue scale and/or asked how justice and a scale are alike, helping him/her assess the correctness of his/her classifications and amend his/her incorrect classifications.

Summary

Do the differences between abstract and concrete concepts involve totally different learning processes and mandate different instructional strategies? This paper has suggested an answer to that question in several parts.

First, the use of prototypes was described as the currently accepted way in which concepts are learned. According to this theory, concept information is distilled into a single representation abstracted from a collection of specific instances. This prototype is stored in memory and used to stimulate recall of concept information during the classification of new instances.

Second, the nature of abstract concepts was described with particular attention given to the instructional problems caused by their ambiguous, intangible nature. Because abstract con-
cepts do not have tangible attributes or clear-cut instances it is difficult, at best, to generate an effective prototype to use in the storage and retrieval of concept information. As a result, learning abstract concepts is more difficult.

Third, the use of analogies was introduced as a way to generate a useful substitute for a concept prototype. Using an analogy concretizes the ambiguous, intangible attributes of the abstract concept and helps to generate a single composite image that serves the same storage and retrieval functions as does a prototype.

Finally, a sequence of prescriptive guidelines was suggested for the design and use of analogies in teaching abstract concepts.

It can be seen from this that, while abstract and concrete concepts are qualitatively different, the processes involved in learning them are essentially the same. In each case, what must be acquired is the capacity to classify new instances according to the set of attributes that define the concept, that distinguish members of the concept category from non-members. The problem lies in the fact that the attributes of an abstract concept are more difficult to encode and hold in memory. The key to facilitating abstract concept acquisition is to find a way to utilize the power of prototypes as holders of a concept's defining attributes. It has been postulated here that using an analogy helps in the formation of a prototype substitute by concretizing the abstract concept. The prototype substitute represents the abstract concept in memory much as a prototype represents a concrete concept. Using an analogy in this way adds a step to the process of concept acquisition rather than altering it in an essential way.

Analogies are common and accepted in education. Further empirical study is needed, however, along two related lines of investigation. First, are analogies effective? Do they reliably result in improved learning and retention? Are they more effective with certain types of content than with others? The present paper has suggested that analogies are useful in learning abstract concepts. This needs to be verified empirically. Perhaps other types of content will be found to be similarly appropriate for learning by analogy. Second, how can the effectiveness of analogies be maximized? How should they be constructed and presented to the learner? The present paper has offered a set of prescriptions for the construction and use of analogies in instruction. Research is needed to substantiate these or other prescriptions in order to establish valid and reliable guidelines. One interesting practical aspect involves assessing the comparative advantages of teacher-generated and learner-generated analogies. Teacher-generated analogies may be more quickly developed and presented. Learner-generated analogies, however, may better ensure that the new concept will be related to something familiar and memorable to the individual learner. Knowing when and how to use teacher-generated and learner-generated analogies is the type of practical information that will be most useful to the instructional designer and teacher.

References


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