A New Model of Concept Teaching and Learning

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Current models of instructional design assume that concepts are (a) classifying rules, (b) components of a more complex network or schema in memory, and (c) evaluated/taught by classification performance. Based on current research and theory, however, concepts should be viewed as conceptual tools rather than classification rules. Concepts may be schemas or networks in themselves, as a complex arrangement of declarative, procedural, and inferential knowledge. Concept learning may be measured by concept use and inferences as well as classification and taught via analogies, learning strategies, use/inference practice, and rational-set generators.

☐ Because the title of this paper suggests a new concept model, we should perhaps first explain what we mean by "model." In particular, the concept model we address is the set of assumptions, data, and inferences used in instructional design for concept learning. Components of this design model include assumptions about:

- the nature of concepts,
- the way concepts are learned,
- how concept learning is measured, and
- how conditions should be designed for concept learning.

This paper will explain how, in light of recent concept learning research and theory, each of these design model aspects warrants revision, thus creating a new model of concept learning.

ASPECTS OF CURRENT DESIGN MODELS

The Nature of Concepts

Concepts represent, in a general way, the learner's categorization system. They are a means for the learner to impose order and meaning on the world. Concepts have been operationalized by instructional design theorists to indicate types of classifying rules (R. C. Anderson, 1973; Gagné & Driscoll, 1988; Gagné, Briggs & Wager, 1987; Merrill & Tennyson, 1977) that are used to facilitate the classification or identification of instances (Reigeluth, Merrill & Bunderson, 1978;

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Klausmeier, 1980). Definitions, attributes, and examples are acquired to facilitate this process. Concepts can be divided into two broad categories: concrete and defined (Gagné & Driscoll, 1988).

How Concepts Are Learned

Concrete concepts represent natural categories, that is, categories determined on the basis of perceptual features. "Bird" (an object in the environment) and "round" (an object quality) are examples of concrete concepts. Defined concepts, by contrast, are those that represent semantic categories that may or may not have a perceptual basis. For example, "uncle" cannot be identified on sight, but rather, must be defined. It is certainly true that some concepts may be both pointed out directly and later identified by means of a definition. "Triangle," for example is most likely distinguished initially from other, unlike shapes such as circles, and later learned as a "3-sided polygon." It is often the aim of education to expand concrete concept understandings with their corresponding definitions so that learners may use the concepts in more abstract ways (Gagné and Driscoll, 1988).

In 1975, Rosch proposed that concepts are represented in memory by their examples, as opposed to an abstract rule or list of concept features. She based her claim on the finding that the most typical members of a category tend to be the first to be identified or accessed from memory.

More recent theorists have focused on the place and function of concepts in the overall structure of memory, suggesting that concepts are stored as declarative and procedural components of a network-like arrangement. Some theorists see concepts as nodes in a network (J. R. Anderson & Pirolli, 1984), while others see concepts as slots of a broader schema (Gage & Berliner, 1988). Concepts have often been shown to be members of a "kinds" or "parts of" hierarchy of class relationships. In each case, concepts are seen as subsidiary components of larger structures of stored information. In each case, learning concepts is thought to involve determining whether new instances belong to an established class or category.

How Concept Learning Is Measured

Consequent with the nature of concepts, concept learning traditionally has been measured by a learner's ability to recognize instances of the concept. Recognition ability depends both on generalizing across examples and on discriminating examples from nonexamples (Tennyson & Park, 1980). To assess both component skills, Tennyson and his colleagues have developed methods of diagnosing practice and test items that measure concept classification and acquisition (Park & Tennyson, 1980; Tennyson, Park, & Christensen, 1985). The history and rationale for classification measures dates to the time of Hull in the 1920s, when classification criteria were used for some of the first laboratory experiments in concept learning.

How Conditions to Promote Concept Learning Are Designed

The primary mode of concept teaching has centered around the presentation of a definition or defining attributes, along with a set of examples and nonexamples, followed by practice in classifying examples/nonexamples (Tennyson & Cochiarella, 1986). In addition, presentation strategies such as attribute isolation and mnemonics aid learning of declarative knowledge such as concept definitions (Reigeluth et al., 1978), while the selection and sequencing of practice examples develops procedural skills in generalization and discrimination (Tennyson & Park, 1980; Driscoll & Tessmer, 1985).

Today, much instructional design from concept learning proceeds with most or all of the preceding assumptions implicit. This is true in business and military settings as well as elementary education (Joyce & Weil, 1985; Hunter, 1983). Current research, however, particularly in cognitive science, points to new conceptions of the nature and acquisition of concepts, and to how to measure and teach them. As we discuss in the next section, concepts are learned and used for more than classification and should be taught through interventions that develop these nonclassificatory uses.

DEPARTURES FROM THE TRADITIONAL CONCEPT MODEL

The Nature of Concepts

We begin with the assumption that concepts represent categories, but defining them as classifying rules is too restrictive. Rather, they should be construed as categories that serve as cognitive tools. A concept is more than the rule used to find its members. Indeed, defining a concept merely as a classification rule is like defining theory as rules for theorizing, or procedure as step-following. As Brown, Collins & Duguid (1989) indicate, conceptual knowledge is more like a set of tools used for different contextual purposes than a collection of abstract definitions. Researchers such as Klausmeier (1980) have explained that the uses of a concept involve more than classification. Pollock (1974) and other epistemologists have long held that understanding the meaning of a concept means understanding its uses. Certainly, concepts are still ideas, but the function of conceptual knowledge in and of itself transcends example classification.

How Concepts are Learned

Concepts have both declarative and procedural components and, thus, require instruction that suits both declarative and procedural learning outcomes. Declarative strategies typically seek to make the information surrounding the concept personally meaningful to the learner (cf., Reigeluth, 1983), such as explaining the origin of the concept or providing a mnemonic to help recall a definition. Procedural strategies, such as repeated practice with response-sensitive feedback, are aimed at producing accurate and easy performance of concept-classification skill (Salisbury, Richards, & Klein, 1985).

Over time, a concept may become a schema or network itself, instead of a node or component of one. In many cases, concepts such as "giftedness," "cost-benefit analysis," or "glasnost" may have an enormous amount of declarative and procedural knowledge attached to them, what Carroll (1964) has called the "cognitive and affective components of concepts." Such concepts are not so much learned through definitions as acquired over time (Brown et al., 1989) through use and experience.

Moreover, the way that these conceptual tools are used depends upon the context of use (Whitehead, 1954; Carroll, 1964; Barsalou, 1985). This suggests that learners acquire declarative and procedural knowledge for the specific settings in which they use a given concept. As knowledge is acquired about the concept, learners themselves infer further knowledge about it (Camp, Lachman & Lachman, 1980; Lehrer & Koedinger, 1988; Naveh-Benjamin, et al., 1986). Thus, a single concept in memory may eventually contain a definition or defining attributes, examples and nonexamples, procedures for classification/identification, connections to related knowledge, emotive connotations, and rules for use in certain contexts. In this sense, a concept seems to become more like a schema (Slavin, 1986; Howard, 1987) in the way information is organized around a single theme, the concept name.

The database on a single concept can be "rich in content and complex in form" (Tversky, 1977, p. 329) or "encyclopedic" (Shalevson, 1974, p. 236). Most important for instructional design, the uses of a concept and its connection to related knowledge are part of its makeup, and must be measured and taught. Failure to teach these additional elements could lead to students who can classify cases in a rote way, but cannot make use of the concept in problem-solving situations.

How Concepts Are Measured

Traditionally, concepts have been measured by means of concept classification or identification tasks. This kind of measure certainly suits training tasks such as tank identification or laboratory tasks such as dot pattern recognition, but are there other valid measures of "really understanding" a concept?

Students who can define, describe, give examples, and relate the concept to other knowledge are demonstrating their learning of the concept. We would claim that students who cannot do these things may have a deficit in their understandings that will inhibit meaningful encoding and creative use of the concept.

Two concept performance measures that reflect "higher" kinds of cognitive activity are: using a concept (e.g., writing stories or sentences, role playing) and generating inferences about a concept (e.g., theorizing, drawing implications, understanding context). These uses and inferences reflect a conceptual-tools view of concept learning, where the inferences drawn from concepts (J. Wilson, 1971; Shavelson, 1974; Smith & Medin, 1981) and the uses of the concept (Markle, 1975; Brown et al., 1989) are part of the purposes and determinants of concept learning. To say that these measures are not valid because concepts are classification rules is to beg the question and ignore the learning goals of instructors and educators.

How can concepts be measured through use? There are several possibilities, some of which are echoed by other researchers:

- Using the concept in conversation, writing, and argumentation: to communicate intelligently about the concept (Brown et al., 1989);
- Simulating or role-playing the concept (Tessmer, Jonassen and Caverly, 1989); and
- Making judgments or criticisms on the basis of the concept.

In all cases, the emphasis is on the use of the concept as a tool. Students learn the defined concept "justive" not just to identify examples of justice and injustice, but to employ the concept intelligently.

Inference-making requires students to reason spontaneously using the concept, making connections between information not previously stored contiguously in memory. In generating inferences, students make associations between things that were previously unassociated or weakly associated. Three inference types are:

- Inferences about membership of the concept in superordinate categories, since a concept may have numerous superordinate class memberships (R. Anderson & Ortony, 1975). For example, can a chair be a gift? Is it a form of transportation? Is psychology a science (J. Wilson, 1971)? This type of inference is a measure of alternative conceptions of the concept.
- Inferences about properties or functions of the concept that are not directly given as defining attributes. For example, can you take a bath in a restroom? If humans are featherless bipeds, do they necessarily have skin? Does glasnost entail a reduction in armed conflicts between two nations? If canaries can sing, can they breathe (Markle, 1977)? Do basketballs float (Barsalou, 1982)? These examples may seem farfetched for instruction, yet often people must reason in these ways to solve novel problems, whose solutions lie beneath the "surface" knowledge they bring to bear. By generating inferences, people broaden their knowledge about a concept.
- Inferences about relationships between other concepts that are at the same level of generality as the target concept but are not coordinate concepts of the immediate set. For example, does task analysis cause/facilitate/hinder formative evaluation? What does a G-sharp on a piano sound like to you (analogical inference of a concrete concept)? How might the rise of desktop publishing and electronic communications affect scholarly productivity among faculty?

In addition to the preceding examples, inference questions may also be used to measure conceptual relationships such as causation, proximity, parts, operations, and precedence (Collins & Quillian, 1972; Shavelson, 1974; Reigeluth, 1983). These questions also measure the presence and strength of semantic relationships in a concept network or schema, and elicit learner practice in drawing inferences. The type of inferences elicited during instruction depends on the purposes of the instruction, the prior knowledge of the learner, and the age of the learner, since preadolescents do not generate inferences as readily as older students (Wagner & Rohwer, 1981).

NEW METHODS FOR TEACHING CONCEPTS

To summarize our discussion so far, concepts are more than classification rules and can be schema-like in their construction, and the uses and inferences of concepts are viable measures of concept knowledge. Thus, in many cases concept instruction should be designed to facilitate more than classification performance; it should be designed to foster the proper schema-like connections with prior knowledge, and to encourage inference and use productions as well. To do this several instructional strategies can be employed:

Teaching with Analogies

Analogies enable learners to connect novel conceptual information with their prior knowledge, thus establishing a familiar structure for the new concept. Concept instruction through analogy can be so powerful that the proper analogy must be carefully chosen (Striley, 1988), and its boundaries (comparatives) to the concept explained (Feltovich, Spiro, & Coulson, 1988).

Several theorists prescribe the use of analogies for defined (abstract) concept learning (Ortony, 1975; Newby & Stepich, 1987). Analogies, however, can also be used for concrete concepts. This is worth noting because designers sometimes seem to forget that visual/aural/tactile (concrete concepts) can be as complex and/or difficult to learn as defined concepts. Biederman & Shiffrar (1987) present an interesting illustration of this point. They cite an analogy used by chicken sexers, who cultivate their subtle identification skills over years of experience. To identify male chickens, genitals are conceptualized as looking like a watermelon or a ball, while a female's look like an upside down pine tree (p. 643).

Use of Learning Strategies

Various learning strategies can be used to aid the encoding of concept information. Concept mapping and structuring (Jonassen, 1984; Vaughan, 1984; Tessmer and Jonassen, 1988) help students organize definitions, examples, and properties of concepts as well as semantic/inferential relations among other concepts. For classification tasks, advance task instructions on learning and performance expectations can activate concept learning strategies in students (Ellis et al., 1986). If concept inference or use is an objective of the instruction, these advance instructions may help the learner to generate the proper productions for inferences and uses in the concept schema.

Use and Inference Practice

Programs such as the Higher Order Thinking Skills program (Pogrow, 1985) have successfully encouraged students to manipulate conceptual information through creative use, using the concept in various symbol systems and contexts to broaden their meanings. For example, using the concept of reinforcement in laboratory experiments, teaching, and business contexts can broaden the learner's understanding of what reinforcement entails, which can promote the learner's further use of the concept in contexts not originally studied (e.g., for self-management).

Using a concept in different symbol systems occurs, for example, when learners read about the social hierarchy of whales and generate sketches depicting their understanding of "hierarchy." This process of translating from one code to another—in this case, verbal to visual—has been termed *transmediation* (Suhor, 1982) and has assisted learners in gaining new insights and broadened understandings about concepts (Siegel, 1985).

Concept-use instruction can proceed through several stages. Learners can begin by paraphrasing the concept definition or attributes (R. Anderson, 1973) and conversing about the concepts (Markle, 1975; B. Wilson & Tessmer, 1989), then move to using the concept in conversations and other communications, and finally to using the concept with other declarative or procedural knowledge to solve problems (B. Wilson & Tessmer, 1989).

For inference instruction, the inference measures outlined in the previous section serve as patterns for the types of inference practice that can be provided. Students can be provided with learning guidance (context cues) to generate inferences about what is learned (Pogrow, 1985). Indeed, if learners are expected to acquire more than classification performance, guided practice in inference making and/or use must be provided.

NEW STRATEGIES FOR CLASSIFICATION PERFORMANCE

A variety of alternate presentation strategies can be used to supplement the standard definition-plus-examples/nonexamples strategies used in example classification training. Many of these strategies have been advocated by instructional theorists over the years.

For example, displaying coordinate concepts in structural outlines such as concept trees has facilitated coordinate concept classification (e.g., Tessmer & Driscoll, 1986), and may be particularly effective with adult learners (Bower, 1970). For classification practice, concept games and simulations represent a little-used strategy that puts the learner into scenarios that elicit classification performance in ways that differ from standard concept example practice (Tessmer et al., 1989). Particularly, concept simulations mimic the real-world situations in which the learner will use concept classification, increasing the probability of transfer. To create concept examples/nonexamples that maximize generalization and discrimination, the Rational Set Generator (Driscoll & Tessmer, 1985; Tessmer & Driscoll, 1986) can be used to design sequences of coordinate concept examples and nonexamples.

Hierarchical displays facilitate the learning and organization of the declarative component of concept classifying, while rational sets, games, and concepts facilitate mastery of the classification skills of concept learning (R. Anderson, 1985; E. Gagné, 1985). When used with analogies and with use and inference practice, these interventions extend what Reigeluth (1983) calls the "meaningfulness of the concept."

Determining Qualities of Concepts to Be Learned

While the distinction between defined and concrete concepts is a well-established part of instructional design, a more fine-grained analysis of concept qualities leads to more appropriate instruction. The complexity of concepts is an important dimension to consider, for example. Complexity is determined by the amount and unfamiliarity of information to be learned to meet concept-learning objectives.

Contrary to Newby and Stepich's (1987) emphasis on abstract (defined) concepts, concrete concepts may be as complex and difficult to learn as defined concepts, as indicated in the chicken sexing sample. Concepts may also vary in their precision; many everyday concepts are ill-defined or "fuzzy," defying standard definitional instruction (B. Wilson, 1986), such as concepts such as "time" or "esprit de corps." Concepts may be relational, conjunctive, or disjunctive, each requiring appropriate instructional support. Most important, designers must learn to classify concepts by the content and purposes of the instruction; the meaning of any given concept and its learning objectives frequently depend on these two factors, not upon a standard invariant meaning and standard classification performance. The design of instruction must then match instructional strategies with the particular outcomes selected.

Finally, the way people use concepts is context dependent (Whitehead, 1954; Carroll, 1964; Barsalou, 1985). Thus, just as context is examined in a front-end analysis for large-scale instruction projects, so context should be analyzed when teaching concepts (Tennyson, 1977). What are the different uses of the concept by someone who "really understands" it? What are the variable subjects or situations in which it will be used? These are context-analysis questions.

CONCLUSION

In this paper, a new way of looking at concepts has been presented that takes into account the declarative and metacognitive components of concept learning and use. Implications for instruction have been outlined. The paper is largely a response to traditional concept teaching models that focused nearly exclusively on the procedural components of concept use. Using R. Gagné's (1985) taxonomy of learning outcomes as an example, we are recommending that the "intellectual skill" of concept using be combined with the "verbal information" that makes the concept meaningful. Concepts taught in this broader way will be more likely to be used in realistic performance situations.

The obvious danger in broadening the view of concepts and concept teaching is that the notion will become ill-focused and lack prescriptive power. On the contrary, a broader approach to concept learning can help bring our instructional models back into alignment with everyday teaching and learning. A continuing effort to articulate instructional strategies such as inferences, simulations, scenario-based instruction, and case studies will help concepts come alive for learners. □

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