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Psychology of Learning for Instruction

Marcy P. Driscoll

Third Edition

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of accretion. The egg-beating schema remains unchanged, but the variable for implement has been filled with blender.

When existing schemata evolve to become more consistent with experience, then **tuning** has occurred. Rumelhart and Norman (1978) suggested that this process accounts for the minor schema modifications that come with new exemplars of concepts and principles. Adding to one's egg-beating schema, the information about how long to beat for mayonnaise versus omelets is an example of tuning.

Finally, **restructuring** involves *the creation of entirely new schemata which replace or incorporate old ones.* This may occur through schema induction (Rumelhart, 1980), in which a new schema is configured from repeated consistencies of experience. Or, as Rumelhart and Norman (1981) argued, restructuring occurs most of the time through learning by analogy. In this case, a new schema is created by modeling it on an existing schema and then tuning it to fit the new situation. What typically occurs, according to Rumelhart and Norman, is that learners will try to use an existing schema to interpret the new situation, as did the child who initially applied her understanding of whipped cream to the mayonnaise problem. Areas of mismatch suggest ways in which the new schema must differ from the old, while areas that were not contradicted are carried over into the new schema.

Schema Automation and Cognitive Load

The notion of cognitive economy surfaced in Ausubel's thinking when he wrote about retention and forgetting. Recall that it is easier—more economical—to remember an inclusive concept or anchoring idea than to remember all of the details associated with it. Because schemata are conceived as packets of knowledge with slots to be filled with relevant, associated details, they are, by definition, an economical means of storing information. When schemata also become automated, processing capacity is freed so that more working memory can be devoted to tasks such as comprehending text or solving problems. This integration of concepts from information-processing theory and schema theory is the basis of cognitive load theory (Kirschner, 2002; Paas, Renkl, & Sweller, 2003; Sweller, van Merrienboer, & Paas, 1998).

Cognitive load refers to the strain that is put on working memory by the processing requirements of a learning task. When learners encounter a task for which they do not have an appropriate or automated schema, they must hold in mind all elements of the task individually and simultaneously. Think back to the examples given earlier in the chapter of readers constructing interpretations of text. If a schema to aid comprehension is not called to mind immediately, then the reader must struggle to remember each sentence in the paragraph as he or she attempts to construct a schema. However, comprehension proceeds with ease when an appropriate schema is automatically acti-

vated and brought to bear on the reading task. Similarly, in problem solving, learners who already possess an automated schema or mental model have more processing capacity in working memory to apply that schema toward solving more sophisticated problems. An important question, then, is how to facilitate the construction and automation of schemata that are useful for solving problems of interest (Sweller, van Merrienboer, & Paas, 1998).

Sweller, van Merrienboer, and Paas contend that the general strategies most learners use to solve problems when they cannot activate an appropriate schema put heavy demands on working memory. Furthermore, these strategies (such as breaking the goal into component parts) are only peripherally related to learning. The desired learning goal is for learners to construct and automate the appropriate schema or mental model that pertains to the particular class of problems to be solved. Therefore, instructional strategies should be sought that reduce extraneous cognitive load but increase germane cognitive load (Sweller, van Merrienboer, & Paas, 1998). Germane cognitive load has to do with making sure that learners engage in the cognitive processes required to construct an appropriate schema. How instruction might facilitate meaningful learning and schema construction is discussed next.

Meaningful Learning, Schema Theory, and Instruction

What do meaningful reception learning and schema theory have in common when it comes to implications for instruction? Clearly, prior knowledge plays an enormous role in both theories. What learners bring to the learning situation dictates to a large extent what they will take away from it in terms of new knowledge—concepts added to their cognitive structure or details elaborating schemata. But the content and organization of instructional materials are also important in both perspectives. Materials must be potentially meaningful to learners, organized so that connections are easily made between new information and that which is already known. To conclude this chapter, then, let us consider implications of meaningful reception learning and schema theory for activating prior knowledge, using prior knowledge in new situations, and making instructional materials meaningful.

Activating Prior Knowledge

Most learners already know something about any new topic they are asked to study, or they can make meaningful connections between what they know and what they are being asked to learn. However, possessing relevant prior knowledge is no guarantee that learners will activate and use it appropriately. It has been found in many conventional memory experiments, for example, that participants tend to view information they are asked to learn

as separate and distinct from their prior knowledge (Spiro, 1977). They adopt an experiment set, which means that they approach the learning material in a rote fashion and fail to assimilate the information into related prior knowledge. Unfortunately, all too often learners tend to approach learning tasks in much the same way, regardless of whether they have prior knowledge to apply to the task. I have seen this happen in my graduate courses in which former teachers fail to use what they know about teaching to help them in learning about formal theories of learning and instruction.

In an instructional situation, then, the activation of prior knowledge should not be left to chance. To assure that meaningful learning takes place, instructors and designers can employ a variety of strategies to help learners relate their prior knowledge to new information they are to acquire. Making these connections is what Ausubel referred to as the first function of instruction, and he proposed the advance organizer as a means of accomplishing it (Ausubel, 1963a, 1968; Ausubel et al., 1978).

Advance Organizers. Advance organizers are relevant and inclusive introductory materials, provided in advance of the learning materials, that serve to "bridge the gap between what the learner already knows and what he needs to know before he can meaningfully learn the task at hand" (Ausubel et al., 1978, pp. 171–172). Ausubel et al. (1978) also stated, "organizers are presented at a higher level of abstraction, generality and inclusiveness than the new material to be learned" (p. 171). Consider why this might be so. For one thing, learners are likely to have somewhat idiosyncratic cognitive structures, and while it might be desirable to construct advance organizers for each and every learner to meet their unique needs, that is not a very practical strategy. Thus, organizers should be sufficiently general to function for a variety of learners. In addition, remember Ausubel's call for using the most inclusive and relatable concepts of a discipline to guide learning. Constructing organizers more abstract and inclusive than the learning materials is one way of doing this.

The effectiveness of advance organizers for enhancing learning and retention of verbal materials was a subject of great debate in the research literature, but in spite of contradictory findings, the concept has persisted. Some studies (e.g., Ausubel, 1960; Ausubel & Fitzgerald, 1961; Ausubel & Youssef, 1963; Kuhn & Novak, 1971; West & Fensham, 1976) confirmed the positive effects of advance organizers on learning. Others suggested that the facilitating effect might be limited to learners with low verbal or analytic ability (e.g., Ausubel & Fitzgerald, 1962). But research reviews conducted by Bames and Clawson (1975) and Hartley and Davies (1976) pointed to even more equivocal findings.

Some of the problems cited in the research concerned methodological flaws in conducting the studies. For example, researchers may have failed to ascertain whether the organizers in their studies contained relevant concepts

that would activate existing subsumers. In the absence of analyses of the learners' cognitive structures and the concepts to be learned, Ausubel et al. (1978) argued, it is unlikely that an appropriate organizer could be constructed. Moreover, if criterion tests are either too easy or too hard, or if they are designed to measure verbatim recall, then no organizer effects should be expected.

A more serious criticism of advance organizers is that their definition is vague (Hartley & Davies, 1976). If researchers operationalize the concept of advance organizers in different ways, then it should come as no surprise that their results do not agree. Ausubel et al. (1978) countered this criticism by pointing to the volume of space in an earlier work (Ausubel, 1968) devoted to the "nature and definition of an organizer and how it affects information processing" (p. 175).

Focusing on the conditions under which advance organizers might be expected to facilitate learning, Mayer (1979) reported the results of a set of experiments he conducted to test the claims and criticisms regarding advance organizers. From his results, Mayer suggested that advance organizers should exhibit the following characteristics:

1. Have a short set of verbal or visual information,
2. Be presented prior to learning of a larger body of to-be-learned information,
3. Contain no specific content from the to-be-learned information,
4. Provide a means of generating the logical relationships among the elements in the to-be-learned information, and
5. Influence the learner's encoding process. The manner in which an organizer influences encoding may serve either of two functions: to provide a new general organization as an assimilative context that would not have normally been present or to activate a general organization from the learner's existing knowledge that would not have normally been used to assimilate the new material. (Mayer, 1979, p. 382)

Mayer (1979) went on to suggest that further research is required to determine what analogies, images, and examples in various subject matters may best serve as effective advance organizers. In order for advance organizers to work with particular students as well, they should probably be constructed by the teacher or instructional designer who has specific knowledge about what the learners already know. Mayer concluded with the following checklist for producing organizers to be used in research, suggesting that organizers that generate a yes for each question should be explored further:

1. Does the organizer allow one to generate all or some of the logical relationships in the to-be-learned material?

2. Does the organizer provide a means of relating unfamiliar material to familiar, existing knowledge?
3. Is the organizer learnable, i.e., is it easy for the particular learner to acquire and use?
4. Would the learner fail to normally use an organizing assimilative set for this material, e.g., due to stress or inexperience? (Mayer, 1979, p. 382)

Research on the advance organizer since Mayer's recommendations were published has resulted in greater emphasis on the learners' prior knowledge (e.g., Sui, 1986; Mannes & Kintsch, 1987). Learners must have necessary prior knowledge for the organizer to activate, and the organizer must draw explicit connections between old and new topics (West, Farmer, & Wolff, 1991). Synthesizing Ausubel's ideas with the results of more recent research, West et al. (1991) suggested the following procedures for constructing advance organizers:

1. Examine the new lesson or unit to discover necessary prerequisite knowledge. List.
2. Reteach if necessary.
3. Find out if students know this prerequisite material.
4. List or summarize the major general principles or ideas in the new lesson or unit (could be done first).
5. Write a paragraph (the advance organizer) emphasizing the major general principles, similarities across old and new topics. Examine examples in this text. Use them as models.
6. The main subtopics of the unit or lesson should be covered in the same sequence as they are presented in the advance organizer. (p. 125)

As can be seen in Step 5 and in the example provided in Box 4.1, West et al. have also emphasized the verbal (as opposed to visual) nature of advance organizers. Box 4.2, however, illustrates how visual material may serve effectively as an advance organizer. In this example are two diagrams I have successfully used to introduce different learning theories. These two metaphors tap what individuals know about black boxes and computers and map these onto the major concepts of behaviorism and cognitive information processing. In the former, for example, no reference is made to events or processes inside the learner. In the latter, by contrast, specific hypotheses are made to suggest that such processes are akin to what computers do with information.

Schema Signals. Like Ausubel, schema theorists recognized the importance of activating prior knowledge in learners as they engage in new learning. In reading, for example, comprehension and memory for what is read are facilitated when learners know and can access a relevant schema. This appears to

BOX 4.1 • *Advance Organizer for a Lesson on the Government of the United Kingdom*

Assume that Mr. Amaya's class from the Lesson on Democracy scenario has now completed their lesson on the democratic government of the United States. As a part of that unit, they eventually discussed the three branches of government—executive, legislative, and judicial. In the following advance organizer, these branches are mentioned as a bridge to the next unit on the government of the United Kingdom.

In our unit on the U.S. government we learned that there are three branches in the federal government: the executive, the legislative and the judicial. The primary function of the legislative branch, the Congress, is the passage of laws, whereas the major task of the judicial branch is the protection of citizens' rights under the national Constitution. In this next unit on the United Kingdom, we will learn that there are also these three branches: executive, legislative, and judicial, with similar functions.

(From West, Farmer, & Wolff, 1991, p. 116.)

be true not only for subject matter content but for the structure of the text as well. Many stories in Western culture, for example, share a common abstract structure, which includes an initial setting, adventures of a main character, and resolution of some problem that faces the main character. This story grammar or narrative schema guides both comprehension and later recall of story events (Kintsch, 1976, 1977; van Dijk & Kintsch, 1983; Rumelhart, 1975; Mandler, Johnson, & Deforest, 1976).

People may also develop schemata to guide their understanding of scientific or technical articles (Bransford, 1979; cf. Brooks & Dansereau, 1983). Most of the research articles cited in this book follow a standard schema: introduction to the problem under study, method used to conduct the investigation, results, and discussion. Other basic text structures can include simple listing, comparison/contrast, temporal sequence, cause/effect, and problem/solution (Armbruster, 1986, p. 255). Finally, different schemata may be developed for various literature genre—newspaper stories, detective fiction, etc.

In Chapter 3, the recommendation was made to signal a text's organization to readers. Not only should this help readers pay more attention to important information, but it also provides a foundation for more effective encoding. On the basis of schema theory, this recommendation must be both qualified and expanded. Instructors should alert students to the schematic structures of text materials in order to facilitate their learning, especially when the subject matter is unfamiliar. Poor readers, in particular, can comprehend more of what they read if they are taught to focus on the structure of the text (Varnhagen & Goldman, 1986).