

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 Merriënboer, & 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-

ated and brought to bear by learners who already possess more processing capacity and more sophisticated strategies to facilitate the construction and solving of problems of interest.

Sweller, van Merriënboer, and Norman (1998) suggest that most learners use to solve a problem. They put heavy cognitive load on learners by using strategies (such as breaking down a problem into smaller, more easily related to learning, and automating the appropriate schema for a particular class of problem. It should be sought that reduce cognitive load (Sweller, 1998). Cognitive load has to do with the mental processes required to construct a schema that facilitates meaningful learning.

### Meaningful Learning and Instruction

What do meaningful learning and instruction mean when it comes to implications for learning? It plays an enormous role in both retention and transfer. It dictates to a large extent what knowledge—concepts and procedures—learners bring to a learning task. But the concept is also important in both problem solving and learning. It is helpful to learners, organize information and that which is learned. Let us consider implications for activating prior knowledge, and making instructional materials meaningful.

### Activating Prior Knowledge

Most learners already know what they are going to study, or they can figure it out. They know what they are going to study and what they are going to do. It has been found that prior knowledge is not automatically activated. It has been found that prior knowledge is not automatically activated. For example, that participatory learning is more effective than traditional learning.