

Overview

With the increase in brain-based research in the 1990s, educators sought to advance the connection between neuroscience and education. Although many books have been written about brain-based learning, empirical evidence that supports the educational implications is slim. Cognitive neuroscience is a relatively young field of study, and there is much that we don't know about how the brain learns, thinks, and remembers. We know even less about what happens in the brain when we teach. With these cautions in mind, this section gives a brief overview of some of the fundamental processes in human learning, with suggestions for enhancing students' capacity to retain and retrieve key information.

The basics of information processing are the same for adults and children. The transmission of electrochemical messages between neurons accounts for the transfer of information in the brain. Information is primarily held in two memory stores: working memory (sometimes called short-term memory) and long-term memory. Working memory corresponds to what we are aware of at any given moment. Although there may be individual differences, working memory has a small capacity – seven bits of information, plus or minus two. A typical example of working memory is remembering a phone number – seven digits. The storage capacity of working memory is also fairly short, estimated to be from 5 to 30 seconds.

For the purposes of learning, it is critical that information be converted to long-term memory, which has a much larger capacity to retain information, perhaps for a lifetime. Two types of knowledge are stored in long-term memory: *declarative* and *procedural*.

Declarative (factual) knowledge refers to one's knowing that something is the case. It is represented as propositions (ideas), images and linear orderings. New propositions, or units of meaning, are acquired when they are stored with related units in the individual's existing knowledge network. Thus a requisite for learning is that some meaning be established between new and prior knowledge.

More important than the acquisition of individual facts, we tend to develop schemas, or related chunks of information, that are stored together in long-term memory. Schemas allow us to recognize new examples quickly, to draw inferences about new situations based on this initial

recognition, and to use knowledge stored in schemas to solve problems. Examples of schemas can be as diverse as “quantum physics” to “hats to wear to church.”

Procedural (performance) knowledge refers to our knowledge of how to do things. When we acquire procedural knowledge, we gain cognitive skills that allow us to think, problem solve, and make decisions. Over time, these cognitive skills become automated. Think back to when (and if) you learned to type. At first, you watched your hands carefully and deliberated about which finger to press on which key. The process you used to develop typing skills was controlled, or conscious. Over time, this procedural knowledge became automatized; you no longer had conscious awareness of choosing the correct keys.

The link between declarative and procedural knowledge is that oftentimes the conditions needed to execute these procedures include ideas and schemas. The greater the base of declarative knowledge we possess, the more likely we are to activate appropriate procedures. In addition, information received by the brain is sorted by content or context. Content information tends to be associated with rote learning. Jensen (1996) states that this kind of learning requires intense, continuous effort to keep knowledge fresh. In contrast, context-driven learning forms quickly, is easily updated, and has almost unlimited capacity. Contextual memory refers to information associated with circumstances, locations and emotions. Information that is contextually embedded is easier to learn. Emotions, in particular, tend to increase the strength of memories and help to recall the context of an experience. They are intertwined with reasoning and decision-making. According to Hill, “we literally must feel something is true before it can be believed and learned” (p. 79).

In *How People Learn* (Bransford, et al., 2000) two key findings have implications for teaching both children and adults:

- **“To develop competence in a particular area, students must: 1) develop a deep foundation of factual knowledge, 2) understand facts and ideas in the context of a conceptual framework, and 3) organize knowledge in ways that facilitate retrieval and application” (p. 16).**
- **“Students come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged, they may fail to grasp the new concepts that are taught, or they may learn them to pass a test but revert back to their preconceptions outside the classroom” (pp.14-15).**

Implications for Instruction

Drawing upon the previous section, particular considerations stand out for increasing an instructor's effectiveness with adult learners:

- Research suggests that it is difficult to form schemas from an abstract definition (Gagne, Yekovich, and Yekovich, 1993). *Elaboration* involves adding to the information being learned. Inferences, examples, details, and images all facilitate retrieval by providing alternate pathways for accessing information stored in long-term memory. Careful selection of both examples and non-examples is needed. A non-example can be used to assist schema refinement if it varies in only one way from the designated example.
- H. Simon (1974) has estimated that each new bit of information takes ten seconds to process in order to be stored in long-term memory. The implications for lecture-based instruction are significant. On a neurological level, a 60 minute lecture does not allow students sufficient time to process new information. However, short-term memory is enhanced when information is "chunked" into familiar or meaningful patterns. The organization of course material allows us to divide information into subsets and then recognize the relationship between those subsets; both children and adults tend to do this spontaneously. For example, while grocery shopping, we may organize our acquisitions by produce, dairy products and frozen foods. Not surprisingly, organization processes improve recall in adults as well as children (Gagne, Yekovich, and Yekovich, 1993). To stimulate *organization*, outlines can be given to students at the beginning of class.
- Contextualize content and skills within the learner's real-life experiences.
- Instructional support for learning automated basic skills: the key is to help people take baby steps, that is help them to automate prerequisite procedures and help them compose small procedures into larger ones.
- Questions at the start of a lesson that show the student how the new material relates to something already known can increase learning and recall.

- Find out what students already know. There is a good deal of evidence that learning is enhanced when teachers pay attention to the knowledge and beliefs that learners bring to a learning task (Bransford, et al., 2000).
- It has been suggested that resistance to learning may have a cognitive basis: if students cannot elaborate or organize (that is, connect the information to what they already know), they may lose motivation to learn the topic that is presented.
- Analogies are helpful tools for learning material. For the analogy to be effective, however, the learner must be familiar with the analogous domain. Considering the variability in age and culture among adult learners, it would be wise to ensure that the analogy that makes sense to the instructor is familiar to students.

Additional Resources

Bransford, J., Brown, A., Cocking, R., Donovan, M., & Pellegrino, J. (Eds.). (2000). *How people learn: Brain, mind, experience, and school*. Washington, DC: National Academies Press.

Gagne, E., Yekovich, C. & Yekovich, F. (1993). *The cognitive psychology of school learning (2nd edition)*. New York: Harper-Collins.

Hill, L. (2000). The brain and consciousness: sources of information for understanding adult learning. In S. Merriam (Ed.), *The new update on adult learning theory* (pp. 73-82). San Francisco: Jossey-Bass.

Jensen, E. (1996). *Brain-based learning*. Del Mar, CA: Turning Point.

Jossey-Bass. (2008). *The Jossey-Bass reader on the brain and learning*. San Francisco: Jossey-Bass.

Simon, H. (1974). *How big is a chunk?* Science, 183, 482-488.

Note: This section was developed as part of a more comprehensive paper on adult learning by Diane Harkins.