THE UNIVERSITY AND BEYOND
Teaching for Long-Term Retention and Transfer

Editor's Note: This issue of the Teaching Times features comments from University of Pittsburgh faculty who were invited to reflect on the "10 validated principles" for teaching in the article below by Diane F. Halpern and Milton D. Hakel.*

The preparation of most college teachers consists of in-depth study in an academic discipline, with little, if any, formal training that addresses topics like adult learning, memory, or transfer of learning. The study of human cognition is an empirical science with a solid theoretical foundation and research-based applications that we can use in college classrooms.

How can we apply what research on human learning can tell us to higher education institutions? About 30 experts from different areas of the learning sciences recently met to answer this question. They included cognitive, developmental, educational, motivational, social, cultural, and organizational psychologists, physicists and other science instructors, and representatives from such bodies as the National Science Foundation and regional accrediting agencies.

The empirically validated principles in this article are based on discussions at that meeting. They can be applied regardless of class size or format—in lecture halls, in laboratories, in seminar rooms, or online. As college faculty, we can have a lifelong effect on what our students remember, and, consequently, on what they will think and do, depending on how we design and direct learning activities.

1) The single most important variable in promoting long-term retention and transfer is "practice at retrieval." This principle means that learners need to generate responses, with minimal cues, repeatedly over time with varied applications so that recall becomes fluent and is more likely to occur across different contexts and content domains. Students can practice retrieval by teaching learned concepts and skills to other students, or by responding to frequent questions asked in class or posed online.

2) Varying the conditions under which learning takes place makes learning harder for learners but results in better learning. In the jargon of cognitive psychology, when learning occurs under varied conditions, key ideas have "multiple retrieval cues" and thus are more "available" in memory. For example, educational research suggests that significant learning gains can occur when different types of problems and solutions are mixed in the same lesson, even though the initial learning can take significantly longer.

3) Learning is generally enhanced when learners are required to take information that is presented in one format and "re-represent" it in an alternative format. Cognitive research has established that humans process information by means of two distinct channels—one for visuospatial information and one for auditory-verbal information. According to dual-coding theory, information that is represented in both formats is more likely to be recalled than information that is stored in either format alone.

For example, requiring learners to draw visuospatial "concept maps" makes them (a) create an organizational framework in terms of which to arrange the information they are learning, and (b) communicate this framework visually through a "network" of ideas—both of which are activities that enhance learning. Complex concepts can be related to one another in numerous ways, and depicting correct relationships among concepts is central to all graphic organizing techniques. Similarly, requiring students to write about or explain verbally what they have learned in a mathematical or schematic learning task also takes advantage of dual coding.

4) What and how much is learned in any situation depends heavily on prior knowledge and experience. Psychologists use the term "construction of knowledge" because each learner creates new meaning using what he or she already knows. Thus, the best predictor of what is learned at the completion of any lesson, course, or program of study is what the learner thinks and knows at the start of the experience.

We need to assess learner knowledge and understanding at the start of every instructional encounter, probing for often-unstated underlying assumptions and beliefs that may influence the knowledge, skills, and abilities that we want students to acquire. We also need to test continually for changes in knowledge structures as learning progresses—and look especially for post-learning drifts, because student understanding can easily revert to pre-instructional levels.

5) Learning is influenced by both our students' and our own epistemologies. Academic motivation is related to underlying epistemological beliefs about learning itself and about how learning works. Learning and remembering involve multiple, interdependent processes. Some types of learning occur implicitly, without conscious awareness. Others occur consciously but are relatively easy. Still other types of learning involve considerable effort, and are perhaps even painful and aversive. It is only after an initial investment in the

hard work of learning that additional learning in these fields becomes more automatic, and consequently becomes easier.

Determining the best way for students to learn and recall something will thus depend on what you want learners to learn and be able to recall, what they already know, and what their own beliefs are about the nature of learning. College faculty can help students articulate their implicit beliefs about learning so that these beliefs can be explicitly examined. And based on this knowledge, instructors' construction of the learning task itself can also help students construct new models of how they learn.

6) Experience alone is a poor teacher. What people learn from experience can be systematically wrong. People, therefore, frequently end up with confidence in their erroneous beliefs. Confidence is not a reliable indicator of depth or quality of learning. In fact, research in metacognition has shown that most people are poor judges of how well they comprehend a complex topic.

There is a popular belief that all learning and assessment should be "authentic," that is, nearly identical in content and context to the situation in which the information to be learned will be used. However, missing from most authentic situations—and from most real-life situations as well—is systematic and corrective feedback about the consequences of various actions.

7) Lectures work well for learning assessed with recognition tests, but work badly for understanding. A lecture, in which a lone teacher mostly talks and writes on the board while students take notes, is a satisfactory arrangement for learning if the desired outcome is to produce learners who can repeat or recognize the information presented. But lecturing alone is not optimal to foster deep learning. Understanding is an interpretive process in which students must be active participants.

Learners need "cues" that trigger interpretation and force them to engage the material actively, even if they are sitting silently in a large lecture hall. For example, it is possible to get students to elaborate on information that is presented in lectures by relating it to information that they already know through the use of imagery or probing questions that test for understanding.

The ability to simply recognize a correct answer on an examination is not a good indicator of whether the learner can recognize other instances in which a concept applies outside the classroom. Thus, the type of assessment needs to match the learning objectives.

8) The act of remembering itself influences what learners will and will not remember in the future. Asking learners to recall particular pieces of the information they've been taught often leads to "selective forgetting" of related information that they were not asked to recall.

Principles of learning are difficult to discuss in isolation because learning activities that occur at different times—at the point of initial learning, during the retention interval, and at the point of recall—are all interdependent. They work together to determine what is remembered well after the first recall test is administered. According to standard "memory trace" theories of how we remember, the act of remembering strengthens some memory traces and weakens—or at least fails to strengthen—others.

9) Less is more, especially when we think about long-term retention and transfer. Faculty need to consider carefully the balance between how much and how well something is learned. An emphasis on in-depth understanding of basic principles often constitutes a better instructional design than more encyclopedic coverage of a broad range of topics. If cursory knowledge of a broad area is indeed desirable, as it sometimes is, then learners and instructors should be collectively conscious of this goal so that they can learn and teach in ways that will achieve broad coverage.

But if deep understanding of basic principles is what is wanted, then the teaching and learning process needs to be structured accordingly. This means that instructors and learners must have clearly articulated goal statements that guide instructional design and learning activities. And they must carefully match the learning activities to these goals.

10) What learners do determines what and how much is learned, how well it will be remembered, and the conditions under which it will be recalled. There is an old saying in psychology, "The head remembers what it does." What professors do in their classes matters far less than what they ask students to do.

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