

HOW MEMORY WORKS

Harvard University: The Derek Bok Center for Teaching and Learning

Memory is the ongoing process of information retention over time. Because it makes up the very framework through which we make sense of and take action within the present, its importance goes without saying. But how exactly does it work? And how can teachers apply a better understanding of its inner workings to their own teaching? There are the processes through which we "get information in" (encoding), how we hold on to it (storage), and how we "get it back out" (retrieval or recall). With a basic understanding of how these elements of memory work together, teachers can maximize student learning by knowing how much new information to introduce, when to introduce it, and how to sequence assignments that will both reinforce the retention of facts and build toward critical, creative thinking.

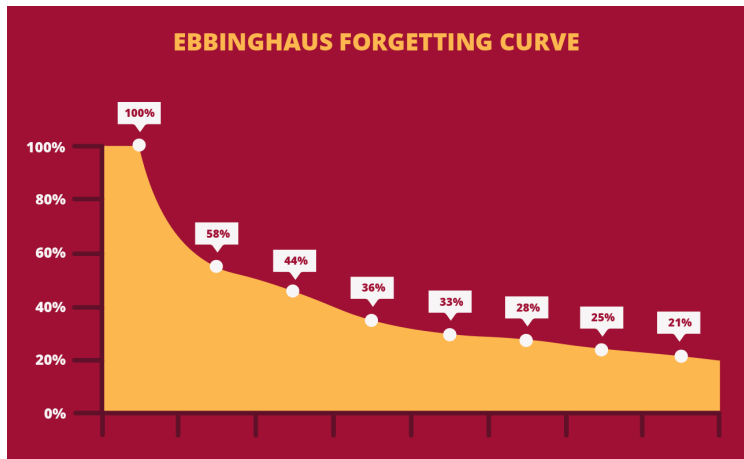
How does Memory Work?

In its simplest form, memory refers to the continued process of information retention over time. It is an integral part of human cognition, since it allows individuals to recall and draw upon past events to frame their understanding of and behavior within the present. Memory also gives individuals a framework through which to make sense of the present and future. As such, memory plays a crucial role in teaching and learning. There are three main processes that characterize how memory works. These processes are encoding, storage, and retrieval (or recall).

1. **Encoding.** Encoding refers to the process through which information is learned. That is, how information is taken in, understood, and altered to better support storage. Information is usually encoded through one (or more) of four methods: (1) Visual encoding (how something looks); (2) acoustic encoding (how something sounds); (3) semantic encoding (what something means); and (4) tactile encoding (how something feels) (Brown, Roediger, & McDaniel, 2014).
2. **Storage.** Storage refers to how, where, how much, and how long encoded information is retained within the memory system. The modal

model of memory (storage) highlights the existence of two types of memory: short-term and long-term memory. Encoded information is first stored in short-term memory and then, if need be, is stored in long-term memory (Roediger & McDermott, 1995). Atkinson and Shiffrin argue that information that is encoded acoustically is primarily stored in short-term memory (STM), and it is only kept there through constant repetition (rehearsal). Time and inattention may cause information stored in STM to be forgotten. This is because short-term memory only lasts between 15 and 30 seconds. Additionally, STM only stores between five and nine items of information, with seven items being the average number. In this context, the term "items" refers to any piece of information. Long-term memory, however, has immense storage capacity, and information stored within LTM can be stored there indefinitely. Information that is encoded semantically is primarily stored in LTM; however, LTM also stores visually- and acoustically-encoded information. Once information is stored within LTM or STM, individuals need to recall or retrieve it to make use of said information (Roediger & McDermott, 1995). It is this retrieval process that often determines how well students perform on assignments designed to test recall.

3. **Retrieval.** As indicated above, retrieval is the process through which individuals access stored information. Due to their differences, information stored in STM and LTM are retrieved differently. While STM is retrieved in the order in which it is stored (for example, a sequential list of numbers), LTM is retrieved through association (for example, remembering where you parked your car by returning to the entrance through which you accessed a shopping mall) (Roediger & McDermott, 1995).



Improving Recall

Retrieval is subject to error, because it can reflect a reconstruction of memory. This reconstruction becomes necessary when stored information is lost over time due to decayed retention. In 1885, Hermann Ebbinghaus conducted an experiment in which he tested how well individuals remembered a list of nonsense syllables over increasingly longer periods of time. Using the results of his experiment, he created what is now known as the “Ebbinghaus Forgetting Curve” (Schaefer, 2015).

Through his research, Ebbinghaus concluded that the rate at which your memory (of recently learned information) decays depends both on the time that has elapsed following your learning experience as well as how strong your memory is. Some degree of memory decay is inevitable, so, as an educator, how do you reduce the scope of this memory loss? The following sections answer this question by looking at how to improve recall within a learning environment, through various teaching and learning techniques.

As a teacher, it is important to be aware of techniques that you can use to promote better retention and recall among your students. Three such techniques are the testing effect, spacing, and interleaving.

1. **The testing effect.** In most traditional educational settings, tests are normally considered to be a method of periodic but infrequent assessment that can help a teacher understand how well their students have learned the material at hand. However, modern research in psychology suggests that frequent, small tests

are also one of the best ways to learn in the first place. The testing effect refers to the process of actively and frequently testing memory retention when learning new information. By encouraging students to regularly recall information they have recently learned, you are helping them to retain that information in long-term memory, which they can draw upon at a later stage of the learning experience.

As secondary benefits, frequent testing allows both the teacher and the student to keep track of what a student has learned about a topic, and what they need to revise for retention purposes. Frequent testing can occur at any point in the learning process. For example, at the end of a lecture or seminar, you could give your students a brief, low-stakes quiz or free-response question asking them to remember what they learned that day, or the day before. This kind of quiz will not just tell you what your students are retaining, but will help them remember more than they would have otherwise.

2. **Spacing.** According to the spacing effect, when a student repeatedly learns and recalls information over a prolonged time span, they are more likely to retain that information. This is compared to learning (and attempting to retain) information in a short time span (for example, studying the day before an exam). As a teacher, you can foster this approach to studying in your students by structuring your learning experiences in the same way. For example, instead of introducing a new topic and its related concepts to students in one go, you can cover the topic in segments over multiple lessons (Brown, Roediger, & McDaniel, 2014).
3. **Interleaving.** The interleaving technique is another teaching and learning approach that was introduced as an alternative to a technique known as “blocking”. Blocking refers to when a student practices one skill or one topic at a time. Interleaving, on the other hand, is when students practice multiple related skills in the same session. This technique has proven to be more successful than the traditional blocking technique in various fields (Brown, Roediger, & McDaniel, 2014).