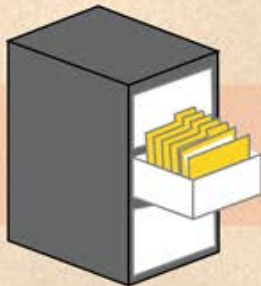# Working Memory

The ability to temporarily hold and manipulate information for cognitive tasks performed in daily life.

Working memory holds information for a few seconds. It is temporary.

Working memory can hold only five to seven items at a time. It has a small capacity.

Working memory holds and manipulates information.

Working memory depends on control of attention and mental effort.

Strategy #1: Use rehearsal, visual imagery, and coding as ways to facilitate the transfer of information from short-term memory to WM to long-term memory.[35]

Rehearsal

Rehearsal is the repetition of verbal information. Verbal rehearsal results in some learning but probably is the weakest of the three strategies for encoding information.[36] Verbal rehearsal can improve a student's short-term memory if there is limited interference and a relatively small number of items to remember. Examples include rehearsing the multiplication tables (9 x 2 = 18), rehearsing a poem, rehearsing the steps of a strategy, and rehearsing the meaning of a word. Repetition may also involve rehearsal using multiple modalities (e.g., tactile, auditory). For example, a student might write down a spelling word several times and tap the equivalent number of letters in the word.

Coding

Coding is the semantic elaboration of information through strategies such as acronyms. Compressing information to be learned facilitates recall.[37] For example, the mnemonic PENS can help students remember the steps of a sentence-writing strategy:

- **P**ick a formula
- **E**xplore words
- **N**ote the words
- **S**earch and check.

The acrostic "**D**on't **M**ake **S**illy **B**ooboos" can facilitate memory of the steps for long division:

- **D**ivide
- **M**ultiply
- **S**ubtract
- **B**ring it down

These strategies make the information to remember more concrete and provide students with a way to attach meaning to the learning tasks.

Visual imagery

Visual imagery is the creation of visual images that help students to remember verbal information. Visual imagery improves memory because students are better able to remember pictures rather than words.[38] For example, visualizing a horse, a boy, and a whale can help a student remember the characteristics of mammals for a test.

The keyword method

The keyword method is a mnemonic strategy using key words to include paired associates learning, is frequently used for vocabulary learning. A *keyword* is a concrete word (e.g., iron) that has phonological similarities with an abstract word (e.g., irony). (Terrill, Scruggs, and Mastropieri suggest steps for developing good keyword links.[39]) Atkinson and Raugh were among the first researchers to show the power of this method on the acquisition of vocabulary.[40] The keyword method has been used by a number of researchers to facilitate student learning and retention.[41] A visual image or drawing and/or a sentence that shows the definition doing something with the keyword can be added to facilitate retrieval of information. Levin, McCormick, Miller, Berry, and Presley provide the example of the Spanish word*carta*, which means *letter*. The keyword could be *cart* and the visual image generated could be of a shopping cart with a letter in it.[42] The following example illustrates how the keyword method might help students remember important information about photosynthesis:

Photosynthesis: a process that converts carbon dioxide into organic compounds, especially sugars, using the energy from sunlight.

- The word "photo" has phonological similarities to "photosynthesis."
- "Photo" is a concrete word, so it becomes the keyword. The Greek word "photo" means light and photosynthesis depends on sunlight to produce sugar (and oxygen).
- To make the connection concrete, generate an image of someone taking a photograph of a plant with a related caption:

A good photo needs sunlight. Image source.

Word to be learned: *photosynthesis*

Keyword: *photo*

Strategy #2: Categorize information by grouping together related objects or events.

Categorization is a form of chunking information that focuses on putting information in meaningful groups. This strategy decreases student WM overload. Consider the following lists of items to remember:

## Strategy #3: Use semantic maps or networks to connect a main idea to related ideas.

Clusters or clustering is an effective way to interconnect what the student already knows with something new and to delineate what is familiar versus unfamiliar, related versus unrelated, superior

versus subordinate. When creating semantic networks, use connecting words and pictures (or videos) to link the main concept to the related networks.

Strategy #4: Use hierarchy to organize information.

Disorganized and random information is not only confusing but also difficult to remember.[46] When it's appropriate, hierarchy is a useful way to structure information to improve recall.

Hierarchical organization of information requires less mental effort from learners, compared to maps that have low structure in which information is not obvious to the learner. Hierarchical maps provide a high degree of structure, which facilitates learning of factual and conceptual knowledge and reduces the cognitive load required for learning new information.[47]
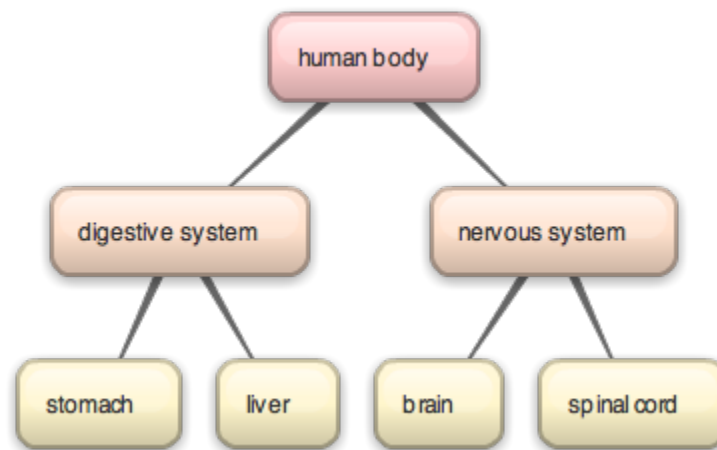
This simplified concept map about the human body organizes information hierarchically .

Strategy #5: Review information frequently.

Without frequent reviews, learners are likely to forget information. Students who review previously-mastered spelling words once a month are more likely to retain the knowledge of that spelling than students who never review spelling words until the end of the year.

Regular review not only helps students to better remember information, but it also allows them to connect prior knowledge to new information. The strategic integration of old and new information helps students to retrieve information from working memory.

Strategy #6: Implement teaching routines and provide a structured and consistent environment.

When students have a structured and reliable environment in which to learn, they know what to expect and do not have to worry about remembering behaviors and routines. This frees student attention and helps students with WM and attention problems organize and process information.[48]

In order to establish such an environment, follow the same schedule daily. Only change the classroom's physical arrangement after informing students of the changes and no more than twice a semester.

Strategy #7: Divide study time into sessions.

Distributing study and practice time across multiple teaching sessions helps students to remember and retain information. For example, students who practice solving new math problems three times a week for fifteen minutes are more likely to retain the information than students who practice solving new math problems only once for thirty minutes following instruction.

Adapted from: ***Using knowledge of student cognition to differentiate instruction*** by Silvana M. R. Watson, Ph.D. and Robert A. Gable, Ph.D.