Information Processing Part I: How do we Learn and How is Information Stored in Long-term Memory?

This past week I had the opportunity to work with Dr. Patricia Wolf, renowned educator and author of Brain Matters, Translating Research into Classroom Practice. Dr. Wolfe is well known for her expertise in understanding the human brain and how it functions. During her intense four day workshop, we explored The Neuroscience of Teaching and Learning. One of the sections I thought was most valuable was her explanation of the Information Processing Model she had designed. This model explains how information is processed in our brains and how the data is eventually dropped or stored into long-term memory.

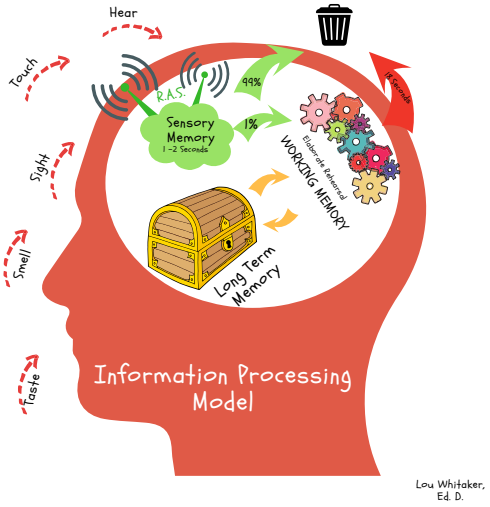
What is learning? What is memory?

According to Dr. Wolfe, "Learning is the act of making (and strengthening) connections between thousands of neurons forming neural networks or maps." While "Memory is the ability to reconstruct or reactivate the previously-made connections" (pg. 18, Wolfe, 2018). So when we learn something new, we're actually creating new connections between our neurons. And when we want to remember something, we call on those neurons to become activated so we can recall what we've learned before.

Neurons that fire together, wire together.
(Hebb's Law)

Sensory Memory

Let's actually take a look at how information gets into our heads and how learning takes place. Data comes into our brains through our five senses; sight, sound, smell, taste and touch. It then goes into an area called Sensory Memory. (Please note; there is no actual area or structure called "Sensory Memory" in the brain, this model is just used to help explain the learning process.)



Your Reticular Activating System (RAS), actually located in the brain stem, takes a leading role in determining what is important and what is not when it comes to paying attention to various stimulations.

They act like antennae. Your senses take in thousand upon thousands of stimuli in a day and it couldn't possibly pay attention to all of it, so it filters out what isn't important and dumps it, while it sends information that you want to pay attention to, straight on to the Working Memory section of the brain. Because we are so over-stimulated by what comes in through our senses, It is believed that we drop about 99% of what comes into the brain and only 1% is sent on to Working Memory (Wolfe P. , 2018). In some very rare visual stimulation situations, the information will go directly to long-term memory (Smith, 2005).

We would go insane if we tried to process all the data our brain receives. So a properly working RAS is essential for learning. Information is only in the Sensory Memory area for about one or two seconds before it is sent to Working Memory or discarded (Armstrong, 2008). So, it's important for teachers to make sure the information students need to know is part of the 1% sent to working memory.

On a side note, many times children with Attention Deficit Disorder (ADD) or Attention Deficit Hyperactivity Disorder (ADHD) do not have a properly working RAS and they receive too much information and sensory distractions are everywhere; a person walks down the hall, someone drops a book, the clock is ticking too loud, they hear a truck drive by, the teacher is talking, someone is whispering in class, etc. By taking a drug such as Ritalin, the brain speeds up so it can quickly filter out what is important and what the brain should discard … thus making the student feel more relaxed, calmer and is now able to focus on what is important ... such as the teacher's voice.

Working Memory

When the brain feels the information it has received is important, it sends it to the Working Memory area of this information processing model. It actually only has about 18 seconds to determine if it wants to throw the information into the garbage or work with it. If it decides that it's pretty important information there is a conscious effort to work with that data and review it over and over until it's ready to move it on to Long-term Memory. Being part of the executive function of the prefrontal cortex, working memory helps us remember moment to moment (Smith, 2005). As new information is taught it must travel through the working memory region of this model (Armstrong, 2008) before it moves on to long-term memory storage.

The main function of working memory is to hold information temporarily and decide what it's going to keep or delete. It also checks to embellish the information or add it to existing knowledge. This is the area where the brain consciously processes information and makes sense of what it is learning. "This increases the probability that the information is remembered and transferred to Long-term Memory" (Wolfe P. , 2018).

So, how does the brain determine if it should keep or delete the information in their working memory?

If a student is overwhelmed with the amount of content in the lesson, he/she may discard important parts of the lesson just because of the overload. The newly presented information may become deleted for other reasons, such as thinking about Friday night's football game. "When a student loses portions of the content or are unable to absorb what is being taught, coherence is threatened because information has gaps and cannot be retrieved for meaning" (Armstrong, 2008). When a student experiences work overload or is "bored to death," teachers need to understand the importance of these memory systems when designing lesson plans. Good lessons avoid the pitfalls of too much content and boring teacher delivery.

Rehearsal strengthens memory through a process called consolidation. This rehearsal strengthens and stabilizes the connections of neurons over days, weeks, months and even years (Wolfe P. , 2018). Teachers must constantly check for understanding while information is being processed in the students' Working Memory to be sure it is complete and accurate.

Dr. Wolfe sums up Working Memory as:

- where information is processed consciously.
- the vehicle for retrieval of all information that is needed to carry out a particular task.
- a serial processor that cannot multitask (watch for my article on multitasking and "The Cocktail Party Effect.")
- the area where rehearsal is conducted. The better information is actively rehearsed, the more likely it is to be transferred to long-term memory (Wolfe P. , 2018).

Long-term Memory

Information is stored in our Long-term Memory section of this model. Data must be recalled or retrieved into Working Memory in order to consciously process it. A good example of this is when my husband and I are driving and while listening to the radio, sing along to songs that were popular when we were back in high school. Even though I can't recall the names of the songs right now, if I heard them playing, I could sing every verse. The songs are pulled into my Working Memory and I remember every word. Neuroscientists believe that once you learn something it is forever stored in our long-term memory. The trick is retrieving information. Can you think of an example from your own experience that might validate this belief? When I smell bread baking, I

immediately think of my grandmother's farm. When I taste Milk Duds, a favorite childhood candy, I think of going to the movies on Saturday afternoons.

Conclusion:

It's important for teachers to understanding how this information process model works. It takes time for consolidation to occur. How long it takes all depends on the information learned and the individual who is studying it. We do know that consolidation does take place and that introducing new information too soon disrupts consolidation of previous learning (pg. 157, Wolfe, 2010). Therefore, teachers need to be wary of specifying time lengths between the introduction of new material. Building elaborate rehearsal strategies into the lessons will give students time to process the information learned in depth. Another way to increase consolidation is to incorporate the new information gradually and repeat it in timed intervals.

When students memorize information for a test, they quickly forget it. This problem is exacerbated when they have so much material to cover in a short period of time. Encoding what they've learned into long-term memory takes time and effort. Watch for my article on ***What are Some Elaborative Rehearsal Strategies That will Transfer Learning into Long-term Memory?***

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