Tellin' Ain't Teachin':

The Need for Frequent Processing

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If teaching were the same as telling, we'd all be so smart we could hardly stand it. (Mark Twain—pen name of Samuel Clemens; American author and humorist; 1835–1910.)

If our academic content is gum, and the discussion and thinking about the content (processing) by students is chew, then brain science gives us a clear directive: Increase the ratio of chew to gum. A lot of gum with no chew leads to little learning.

First, we will overview the neuroscience rationale for increasing the frequency and amount of processing. There are many ways to have students process learning: taking notes, writing summaries, making drawings, discussing ideas. Here I will focus on just one way, what I believe to be the most powerful form of processing: student interaction over the content. After providing the neuroscience rationale for increasing the amount of student interaction over content, we will turn to the issue of *how* best to have students interact. It turns out that some common ways of having students process our academic content do not lead to equitable educational outcomes. These common approaches to processing actually contribute to the achievement gap! If we want all students to benefit from the chew, we must carefully structure their interaction as they process the content.

Neuroscience Support for Frequent Processing

This section summarizes six reasons for providing processing time to students.

1. Processing Clears Working Memory

Working memory has limited capacity: We can only hold a certain amount of information in consciousness at one time (Cowan, 2005). This limit is very adaptive; if we were juggling 100 things in working memory, our attention would be so divided we could not function or survive. Nevertheless, the limited capacity of working memory has extreme implications for educators.

As we lecture to our students, we fill working memory. After about ten chunks of information we have exceeded the limit of working memory's capacity for even the best of our students. The exact capacity of working memory differs for different individuals depending on their age and the complexity of the encoding process that an individual has developed. It differs also for different types of content and whether there are internal or external distractions. In all cases, however, the capacity is quite limited.

As is often said, to continue lecturing beyond the capacity of working memory is like pouring more water into a glass that is already full. If we continue to lecture beyond the capacity of working memory, either the next chunk of input is ignored, or goes in at the expense of something already there. Long lectures reach the point of diminishing returns. Punctuating the lecture with frequent processing repeatedly clears working memory so students can take in new information with undivided attention.

Often, during workshops on this topic, I ask participants if they have ever had so much to do or so much on their mind that they felt “cloudy headed.” That is, they felt they couldn’t concentrate, and couldn’t take in any more information. All hands go up. I then ask how many have had the experience, when they felt like that, of sitting down and writing a To Do list or list of things they have on their mind. All hands go up. Finally I ask, “How many of you, after writing that list, felt much better—felt you could again concentrate, that you could take in new information?” Once again all hands go up, usually with a smile or laugh of recognition. What has happened in those moments? When working memory is full, we know we cannot take in any more information. By writing down what is on our mind, we move things from working memory to the piece of paper, so we don’t have to keep those things in working memory. We clear working memory and so can take in new information with a clear mind. By frequently clearing working memory while we teach, students can attend to a great proportion of our content with undivided attention, rather than with a “cloudy head.” This then provides the first brain-based rationale for frequent processing: *Frequent processing clears working memory allowing for students a greater proportion of full, undivided attention to our content.*

2. Processing Stores Content in Long-Term Memory

During processing students discuss the content, analyze it, and relate it to prior knowledge. They connect the new learning to their own prior knowledge and to the new knowledge provided by those with whom they are interacting. They are actually rewiring their brains, making dendrite connections. The information is placed in more places in the brain, and so there are more associative links. This dramatically increases the probability of later recall.

A person gives us a telephone number to call. We hold the number in short-term memory long enough to make our call. After making the call, someone asks us for the number. We say we can’t remember. It is gone! Why? Content does not move from short-term to long-term memory automatically. The two memory systems are completely independent (McGaw, 2003). To remember the number—or anything else—long-term, we must move the content from short- to one of our long-term memory systems. Each of us has different ways of doing that. If it is a telephone number, some of us look at the relation of the numbers to each other, some of us create a visual image of the number, others of us link the numbers to words or even make a number sentence, and yet others use one of the many mnemonic devices. Whichever process is used, the numbers are placed in long-term memory through thinking about the numbers, processing them. Processing is the golden key to move content from short- to long-term memory.

This then, provides the second brain-based rationale for frequent processing: *Frequent processing moves content from short- to long-term memory, increasing the probability of later recall.*

3. Processing Produces Retrograde Memory Enhancement

Emotion cements memory. Emotion is a signal to the hippocampus: You better remember this! James McGaw and his research team at the University of California, Irvine, established the principle of Retrograde Memory Enhancement (McGaw, 2003). The principle is simple: Anything followed by emotion is better remembered. It is why almost all of us remember where we were when we first heard about the 911 terrorist attacks, but few of us remember where we were the day before or the day after. The principle is rooted in the brain's primary function: survival. What are emotional events? They are the good stuff and the bad stuff; the painful stuff and the pleasurable stuff. Remembering those events helps us survive. Touch the hot stove, and you remember not to do that again. Enjoy the first kiss, and it is likely you will remember it and go back for more.

What does this have to do with frequent processing? Usually, but not always, more emotion is generated in a lively interaction with a peer than is generated by a lecture by a professor. By frequently punctuating the lecture with processing time, the professor links the content to emotion. *Thus, processing releases the power of retrograde memory enhancement to make our academic content more memorable.*

4. Processing Creates Episodic Memories

Usually, a lecture provides facts and information that are stored in the semantic memory system. The semantic memory system handles isolated facts and bits of information. When content for semantic memory is not processed, not put into a meaningful context and internalized, it is far less likely to be maintained. When students cram for a test, too often they are attempting to put information into the semantic memory system, but because they are not fully processing the content they retain the information only long enough to spit it back on the test. A few weeks later, or often much sooner, and the information is gone.

The semantic memory system is more fragile than the episodic and procedural memory systems. Anxiety interferes with semantic memory: that is why sometimes even if we know the name of someone very well, our mind goes blank when we go to introduce them to a group in a social setting.

Procedural and episodic memories are more stable. As we get older we forget the names of things, but don't forget how to drive a car or brush our teeth (procedural memories) or the time we got married or the time we lost our car keys and had to walk home (episodic memories).

What does all this have to do with the desirability of frequent processing? As students interact over the content, they very often create an episodic memory. Why? Episodic memories are created when an event has a beginning and an end as well as a location, especially if there is emotion associated with the event. When students turn to a partner for an animated interaction, the event has a beginning and an end, a location, and is associated with emotion. *Such processing often creates episodic memories that are more stable than semantic memories.*

5. Processing Creates Novel Stimuli, Increasing Alertness

Processing breaks up the routine of the direct instruction, providing novel stimuli. By having students process the content at different times with different partners, we create additional novel stimuli. Further, what a partner might say during the processing time is additional novel stimuli. We become more alert when presented with novel stimuli, providing yet another brain-based rationale for frequent processing: *Processing increases student alertness, which in turn increases the probability of recall of the content.*

6. Processing Activates Many Parts of the Brain

While processing content with a partner, many parts of the brain are activated. Wernicke's area decodes the words of our partner. Broca's area encodes our own words. The temporal lobe processes not only words, but also decodes tone of voice. The visual cortex processes the face of our partner as well as their gestures and body language. Mirror neurons decode the feelings projected by our partner. Further, the prefrontal cortex is very active as we must either assimilate the information provided by our partner or adjust our way of thinking about the world (accommodate) because our partner has provided information that doesn't fit with our cognitive framework. *Thus, processing places the content in more places in the brain, creating more associative links, enhancing memory.*

How We Process Makes all the Difference!

Having grasped the importance of processing, some instructors use a simple "Turn and Talk" approach. They stop talking and ask students to discuss a problem or issue presented in the lecture. What they do not know is that these simple, unstructured interactions actually increase the achievement gap among students!

Picture a highly motivated, high achiever paired with an unmotivated, low achiever. The instructor does a Turn and Talk. Who will do most or even all of the talking? Whose mind will be off topic? When we test later, the motivated, high achiever has benefited from the processing, but the low achiever has not. We have inadvertently increased the achievement gap.

To improve learning and increase educational equity, I began a program in the early 1980s developing cooperative interaction sequences I called Structures. I call them structures because they are carefully designed to "structure" students' interaction patterns. To date my colleagues and I have developed more than 200 different ways of structuring the interaction among students (Kagan and Kagan, 2012). Some structures are explicitly designed to foster the formation of episodic memories; others develop procedural memories, yet others create semantic memories. Still yet others exercise working memory. Let's briefly examine two simple, all-purpose structures that can be used by any instructor for processing during any lesson: RallyRobin and Timed Pair Share.

RallyRobin

Let's imagine an instructor wants students to process the content by naming as many things as they can think of that answer a question. For examples, name all the alternative plausible hypotheses to explain a phenomenon, all the facts covered so far, steps in completing a project, or simply animals found in the rainforest. The instructor could do a Turn and Talk, which often results in the high achiever doing most or even all the talking. Or the instructor could do a RallyRobin: Students in pairs simply take turns contributing to the oral list. By structuring for turn taking, the instructor ensures equal participation and ensures that all students contribute. This reduces the achievement gap.

Timed Pair Share

Sometimes an instructor might want students to speak at length on a topic, say provide an opinion or an interpretation. One structure that allows equal participation for elaborated thinking is a Timed Pair Share. Each student in turn shares for a predetermined amount of time. Again, by using a structure that equalizes participation, we reduce rather than exacerbate the achievement gap.

Tellin' Ain't Teaching

For a variety of reasons, our students remember far more of what they say than what they hear. Listening is passive. While listening to a teacher, not nearly as much goes on in the brain as when students put their thoughts together, verbalize their thinking, and interact with others who might have different information or a different point of view. So, if our goal is understanding and retention, our best course is to frequently stop talking and let our students talk. But then, if we are going to have our students interact, we need to carefully structure that interaction so all students participate about equally. With frequent, carefully structured processing in place, we promote better learning for all students.

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most comprehensive book for educators in each of four fields: cooperative learning, multiple intelligences, classroom discipline, and classroom energizers. Dr. Kagan developed the concept of structures; his popular brain-based, cooperative learning, and multiple intelligences structures like Numbered Heads Together and Timed Pair Share are used in teacher-training institutes and classrooms world-wide.