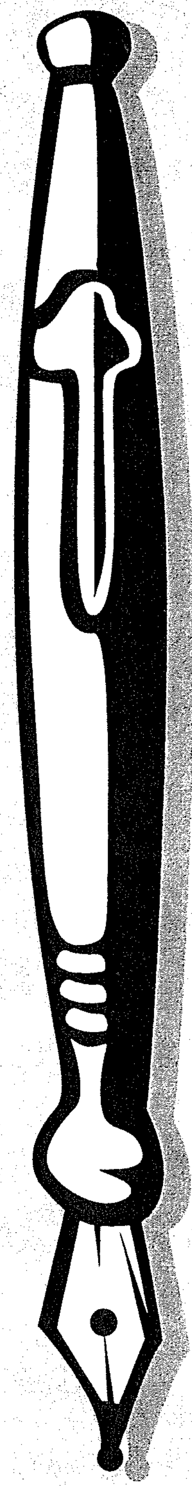

Rethinking Thinking: Does Bloom's Taxonomy Align with Brain Science?

by Dr. Spencer Kagan

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Thoughtful educators know that their students' success in the 21st Century depends on thinking skills. Two trends make thinking skills one of the most important outcomes of schooling. The first trend is the information explosion: The amount of information saved in 2002, mostly on hard disks, is 5 exabytes (5,000,000,000,000,000,000 bytes) or a stack of books 30 feet high for every person in the world.[1] Most of the information our students will deal with on a daily basis during their lifetimes has not yet been generated. Given the information explosion, memorizing one new fact is of little value compared to the ability to understand, analyze, organize, apply, evaluate, and create new information.

The second, related trend is the change rate. Most students entering school today will work in job categories not yet created and all will work with technology not yet invented. The educators of the past had the luxury of preparing their students for a world similar to their own; they could impart the skills and knowledge they themselves found useful, confident the same skills and knowledge would prepare their students well. That is no longer the case. Today, as educators, we have the daunting task of preparing students for a world we can only dimly imagine. If the facts and tools our students will work with have not yet been discovered and invented, our greatest gift is to prepare students with thinking skills — how to understand, analyze, organize, apply, evaluate, new information. We may not know the skills and information our students will need, but we can be certain that if we equip them with a full range of thinking skills we will have provided them an indispensable educational foundation.

For half a century, thinking about thinking among educators has been dominated by a hierarchical model. It is common parlance among teachers to talk about "higher-level" and "lower-level" thinking. This view of thinking has its roots in the work of Benjamin Bloom and his associates. In 1956, they created what today is commonly known as Bloom's Taxonomy.[2] Bloom's Taxonomy describes six types of thinking arranged in a hierarchy, supporting the notion that there are higher and lower-level types of thinking. Bloom's Taxonomy has become foundational knowledge for all teachers and it has motivated educators to develop activities and lessons that foster the acquisition of a wider range of thinking skills. Although Bloom's Taxonomy is very useful from a practical perspective, in three important ways Bloom's Taxonomy does not align well with recent findings of brain science. There are three notions upon which the hierarchy is built, and all three are not supported by what we now know about brain structure and function. In this article, we examine each of these three assumptions in turn, show why each is not supported, and then discuss the need for educators to rethink thinking.

Bloom's Taxonomy

In Bloom's Taxonomy, six types of thinking are arranged from simple to complex; the taxonomy is built on the assumption that the more complex or higher-level thinking skills are built on the simpler or lower-level thinking skills. The skills at the top of the hierarchy have come to be thought of as higher-level thinking skills and those lower in the hierarchy have come to be thought of as lower-level thinking skills.

Table 1: Blooms Taxonomy

Bloom's Taxonomy		
Level	**Type of Thinking**	**Example**
	Evaluation	Which level is most important to develop? Why?
HIGH	Synthesis	Design a project that will engage all six levels.
↑	Analysis	What are all the steps necessary to complete an evaluation?
	Application	Ask a history question at each level of the taxonomy.
LOW	Comprehension	Explain each level in your own words.
	Knowledge	Name the six levels of the taxonomy.

Among many educators this hierarchal notion of thinking has led to an unquestioned acceptance of the idea that there are "high" and "low" levels of thinking: Knowledge and Comprehension are presumed to be less complex cognitively than are Application, Analysis, Synthesis, and Evaluation. Thus Knowledge and Comprehension have come to be viewed as "lower-level thinking" compared to Application, Analysis, Synthesis, and Evaluation, which are accepted as "higher-level thinking." The language with which the taxonomy was presented supports the idea that moving up the hierarchy is equivalent to moving to deeper levels of understanding: "Deeper understanding would be reflected in the next-higher level of the taxonomy."[3]

Some educators and theorists take the hierarchy very seriously; some have even gone so far as to debate the order of the hierarchy, arguing for placing synthesis higher-level than evaluation.[4] The argument: *creative thinking* (coming up with something new —synthesis-level thinking) is more complex than *critical thinking* (analyzing and evaluating something that already exists — analysis- and evaluation-level thinking). Although, the notion of a hierarchy of thinking skills is appealing and seems to have some face validity (simple recall does feel a whole lot simpler than a detailed analysis), in the face of new discoveries about how the brain actually works, it is time we rethink thinking.

The idea that knowledge and comprehension are somehow lower-level thinking than synthesis and evaluation is based on three related ideas: 1) that the presumed "higher-level" skills are based on the "lower-level" skills; 2) that the "higher-level" skills are more complex than the "lower-level" skills; and 3) that the thinking skills described in the taxonomy are discrete and identifiable processes. All three assumptions are not supported by brain science. We will examine each assumption in turn.

Notion 1:
"Higher-level" Skills are Based on "Lower-level" Skills

The idea that thinking skills exist in a hierarchy is based primarily on the assumption that the skills at the higher end of the hierarchy are built on and depend on the skills at the lower end of the hierarchy. In the words of the taxonomy:

> "The whole cognitive domain of the taxonomy is arranged in a hierarchy, that is, each classification within it demands the skills and abilities which are lower in the classification order."[5]

IQ Without Recall. If higher-level thinking skills in Blooms Taxonomy really demanded the lower-level skills, a person's IQ score should drop if their recall is incapacitated. In fact, strange as it may seem, the clinical evidence does not support that finding. The case of Henry, the most investigated subject of medical science, proved the independence of higher level thinking skills from some types of recall. A surgeon removed most of Henry's hippocampus and associated brain structures. Following that, Henry had no recall for incidents that occurred up to two years prior to the surgery, and he could not lay down new memories for incidents that occurred before the surgery.[6] If you met and talked with Henry, you would have to be reintroduced to him the next time you met with him, and again each subsequent time. He simply could not retain new memories. One time while being driven to the clinic, Henry saw a dramatic car accident, Immediately afterwards Henry talked about the accident with considerable emotion. When asked about it twenty minutes later however, he had no memory of the accident at all! His immediate short-term and working memory were just fine, but he could not lay down new long-term episodic memories. If Henry read with great interest a magazine story, the next time he picked up the magazine he would read it with the same great interest and enjoyment, and the next time, and every time he picked up the magazine — he simply had no recall for having read it! Although Henry had no recall for episodes, he could learn new complex mazes just fine. Like anyone else he would improve with each try. The strange thing is that although he could learn to do the mazes perfectly, he had no memory for having ever seen the mazes before! His procedural recall (ability to learn and recall procedures) was just fine, but his episodic memory (memory for incidents) was destroyed. Henry's higher-level reasoning was also just fine. His high IQ score was not impaired following his operation. He actually scored slightly higher on an IQ test after the operation!

The finding that loss of ability to recall new incidents did not lower Henry's IQ is strong evidence that a variety of "higher-level" skills do not depend on the "lower-level" skills. If we believed thinking skills were hierarchical, we would expect that loss of recall would interfere with complex learning and ability to perform the tasks on an intelligence test. In fact, the case of Henry (and others like him) proves presumed "higher-level" thinking skills in Bloom's Taxonomy do not "demand the skills and abilities" of the "lower-level" thinking skills.

Evaluation without Thinking. In Bloom's Taxonomy evaluation is the highest level of thinking, presumed to be based on the thinking skills below it. Yet at least some types of evaluation occurs with no conscious thought at all. The Amygdala is in the center of the brain and has connections to every part of the brain.[7] Among other functions, the amygdala is constantly evaluating the stimuli in our environment, monitoring and responding to potential threats. Without our conscious awareness, the right amygdala fires more rapidly if a tone of voice is threatening; the left amygdala becomes more active if a facial expression is threatening or if we see a snake. When the amygdala is highly activated, a whole cascade of reactions occurs —the fight or flight defense alarm reaction. The amygdala fires more in response to the face of a stranger than someone we know; more in response to someone of a different race than someone of our same race. Even if a person says and feels they have no prejudice toward others of a different race, the amygdala fires more to other-race than same-race faces. All primates jump at the sudden sight of a snake even if they have never before seen a snake! When we see a snake, we jump before we become consciously aware we are seeing a snake. Evaluation is occurring without any conscious recall, comprehension, analysis, application, or synthesis. Thus, at least some types of evaluation are hard wired into the system and are not dependent on "lower-level" thinking skills as dictated by Bloom's Taxonomy. We all have experienced the instantaneous "gut" reaction that tells us if we like or dislike someone or something. As we will see later in this article, not all "gut reaction" evaluations are amygdala based, and some can be even more accurate than ponderous well-considered evaluations.

Higher-Level Thinking without Lower-Level Engagement. If thinking skills were hierarchical, then engaging a higher-level thinking skill would engage thinking skills below it in the hierarchy. In the words of Bloom's Taxonomy:

> As we have defined them, the objectives in one class are likely to make use of and be built on the behaviors found in the preceding classes in this list....[8]

This seems plausible: we can't analyze or evaluate information that we can't recall or comprehend. Active brain imaging, however, reveals that ability to perform discrete thinking skills becomes localized in different parts of the brain and is carried out independently of other skills. Remarkably, when we carry out deductive reasoning, we engage primarily brain structures in the right hemisphere; when we engage in probabilistic reasoning, we engage primarily brain structures in the left hemisphere.[9] Most importantly, there is almost no mutual engagement: One type of reasoning does not depend on another! If thinking skills were hierarchical in the way described by Bloom's Taxonomy, these two types of thinking (probabilistic and deductive reasoning) would each depend on common lower-level thinking skills and so would show a fair amount of common activation. That simply is not how the brain works. Areas of the brain become specialized for specific tasks and performance of each task depends on the activation of specific areas of the brain independent of each other and independent of areas associated with presumed "lower-level" thinking.

That thinking skills are relatively independent of each other has profound implications for our thinking about thinking. Based on brain science, it is no longer meaningful to speak of higher and lower-level thinking skills; rather we need to think in terms of discrete thinking skills associated with discrete patterns of brain function, one skill not dependent on another.

Our Everyday Experience. Additional evidence against the notion that higher-level thinking skills necessarily engage or are "built" on lower-level thinking skills comes from our everyday experience. We all know the person who has incredible recall, but is not good at or inclined toward evaluation. But we also know the person who is very inclined toward and skilled in evaluation (they drive us crazy weighing all the pros and cons of an issue), but they do not necessarily have a good memory. Highly developed evaluation skills are not dependent on highly developed recall skills. A person can be high or low on any of the thinking skills; each person has her/his unique pattern of thinking skills.

Notion 2:
"Higher-Level" Skills are More Complex than "Lower-Level" Skills

Bloom and his associates thought of the thinking skills much the same way a chemist thinks of elements and compounds. Recall was an element. When you add to recall additional skills, you obtain comprehension. When you add to comprehension additional skills, you become capable of application, and so on. Thus each successive level in the taxonomy was thought of as more complex, consisting of more elements. In the words of the taxonomy:

> Our attempt to arrange educational behaviors from simple to complex was based on the idea that a particular simple behavior may become integrated with other equally simple behaviors to form a more complex behavior. Thus our classifications may be said to be in the form where behaviors of type A form one class, behaviors of the type AB form another class, while behaviors of type ABC form still another class. If this is the real order from simple to complex, it should be related to an order of difficulty....[10]

Given this conceptualization, it is no wonder that each successive level in the hierarchy was thought of as higher-level thinking. As neat and appealing as is this concept, it is not supported by brain science.

Each Thinking Skill Can Be Simple or Complex. At first glance it makes sense to think of recall as less complex than evaluation. It feels like we recall effortlessly (memories just pop to mind), whereas evaluation takes concentration, and a good evaluation involves careful weighing an outcome against one or more criteria. Upon reflection, however, we discover any of the thinking skills can be very simple or very complex depending on how deeply we engage that particular type of thinking. If I ask you if you like chocolate ice cream (an evaluation level question), the answer simply pops to mind as immediately and effortlessly as if I ask you if you ate chocolate ice cream within the last hour — a recall level question. If I ask you to recall all the times in the last month you ate or saw ice cream, the answer demands a great deal of cognitive effort, just as if I asked you to evaluate all the pros and cons of eating ice cream. Evaluation, recall, and any other thinking skill can be engaged at a simple or complex level. *Complexity is not associated with the type of thinking skill, but rather with level at which the thinking skill is engaged.*

Table 2: Complexity Within Thinking Skills

Complexity Within Thinking Skills		
	Simple Thinking	**Complex Thinking**
Recall	Did you eat ice cream today?	What are all the things you ate yesterday?
Evaluation	Do you like ice cream?	Give all the reasons you can think of why eating ice cream is good, all the reasons you can think of why eating ice cream is bad, and give a weight to each.

"Higher-Level" Thinking Isn't Always Complex. Evaluation can occur at many levels. We can respond to the question, "Was that a good decision?" with a simple 'gut level' yes or no, or we can respond by creating a very complex matrix of positives and negatives weighed against an array of criteria, each of which in turn are given different weights. An immediate gut level evaluative response occurs with little conscious forethought. Most of us can answer the question "Do you like George Bush?" with no more conscious effort than we give to a simple recall question like "Did you go shopping today?" We simply know the answer — pro or con — without conscious deliberation. There is no cognitive complexity involved when we respond to most "Do you like it?" questions — we just know the answer. Further, gut level evaluations even of very complex issues are not necessarily inferior to conscious deliberations. In his forthcoming book, *Blink: The Power of Thinking without Thinking*,[11] Malcolm Gladwell, provides evidence that snap judgments can be just as good as cautious, deliberate evaluations. For example, among art experts, in deciding if a statute was a fake, instant intuitive evaluation of a Greek statue was superior to painstaking chemical analysis! Of course, years of experience underpin the "intuitive" evaluations of experts and very complex brain processes are responsbile for their success. Nevertheless, the intuitive snap judgment simply pops to mind as easily as does a snap recall. We now know very complex brain processes operate in the background whether we are engaged in recall, evaluation, or any other thinking skill. *From the point of view of brain function, there is no such thing as a cognitive skill that is not complex!*

Notion 3:
The Skills Exist!

If we are to build a hierarchy in which the first level is A, the second level involves A+B, the third level involves A+B+C, and so on, then A and B and C each must be distinct entities or processes. If, for example, comprehension is based on recall, then recall must exist as a distinct process. If there is no one brain process called recall, then the hierarcy comes tumbling down. It turns out brain science unequivocally reveals exactly that — there is no one thing called recall. There are many distinct types of recall, each associated with different brain structures and processes, each operating quite independently of the other! Recall, as a single process does not exist. This poses an insurmountable problem for Blooms Taxonomy: It isn't possible to argue that the supposed "higher-level" thinking skills are built on something that does not exist as a single entity.

Memory is Not a Place; It is Many Processes. When Bloom's Taxonomy was developed, it was meaningful to talk about recall as if it was one thing. When we remember something, it feels like we go into the file cabinets of our mind, open a drawer, and pull out the stored information. We now know much better: Memory is not a place. Rather it is many distinct processes, each of which may be engaged or not, depending on the type of memory involved. Recall of facts engages the semantic memory; recall of procedures engages the procedural memory; recall of incidents engages the episodic memory; recall of how to get from place to place engages spatial memory, recall of a thought we just had involves working memory — and each of these types of recall is associated with very different brain structures and processes. Surgery or an injury can impair or even eliminate the ability to engage in any one of these types of recall while leaving the others completely unimpaired.

In our own work on memory we use the acronym SPEWS to help us remember five distinct memory systems.[12]

Table 3: Memory Systems and Brain Structures

	Memory System	Associated Brain Structures
S	Semantic	Temporal Lobe
P	Procedural	Putamen
E	Episodic	Hippocampus and reated structures
W	Working	Frontal Lobe
S	Spatial	Right Hippocampus

To speak of the "higher-level" thinking skills as if they were based on the "lower-level" thinking skills assumes the "lower-level" skills exist as discrete entities or processes. In fact, there are many distinct processes associated with each of the Bloom's types of thinking. Therefore to say evaluation or synthesis is based on recall masks the underlying complexity. Depending on the task and the experience level of the person performing the task, one, many or none of the recall processes may occur while we engage in application, analysis, synthesis, or evaluation. A simple hierarchy cannot handle this complexity.

Implicit and Explicit Recall. The brain is mini-modular in the extreme: Not only are there at least five distinct types of recall, each of these types of recall is really not a single process but a combination of various relatively independent processes. That is, episodic memory is not one thing, but a collection of processes, each of which can occur in isolation of the others. Experiments reveal the "double dissociative" principle.[13] That is, we can have recall for the affect of an event without memory of the incidents of an event, or we can have memory of the incidents of an event without memory of the affect associated with the event. The emotional component of an incident is processed by the amygdala while the events of the incident are processed by the hippocampus. To prove the independence of these two components of episodic memory, doctors and researchers have conducted classic experiments on patients with damage to the amygdala or to the hippocampus. Results reveal that the amygdala and hippocampus each process different components of episodic memory. If, for example, a patient with amygdala damage is pricked with a hidden pin as a doctor shakes hand with the patient, the patient will remember the events of the incident well, but is quite willing to shake hands with the doctor again on a subsequent meeting. There is memory for what happened, but no memory for the feeling of pain — no aversive conditioning.

In contrast, a patient with hippocampus damage, but whose amygdala is intact will jump back when the doctor attempts to shake hands a second time, but will not know why they are jumping back! They have no conscious memory of the incidents of the original episode, but they have excellent recall of the emotion associated with it.[14] More formal conditioning experiments reveal the same pattern. Subjects are shown different colored slides and a loud aversive noise is paired with only the blue slide. When tested later, patients who have hippocampus damage have no memory of the experiment, but show a strong startle reaction when the blue slide is shown.[15] Patients with an intact hippocampus, but with damage to the amygdala have excellent recall of the elements of the experiment, but have no fear conditioning. The emotion associated with an event (implicit or non-declarative memory) is stored and recalled by different processes than is the conscious recall of the incident (explicit or declarative memory). Recall is not one thing.

Short- and Long-Term Memory Systems. To further complicate the picture, there is very strong evidence that short- and long-term memories are based on completely independent processes.[16] It does not surprise us to hear we can have short-term memory without long-term memory. What is shocking, though, is to learn that we can actually have long-term memory without short-term memory.[17] Contrary to our phenomenological experience, short-term memory does not turn into long-term memory. We have independent short- and long-term memory systems! The long-term memory system takes a longer time to consolidate (we recall better after sleeping on it), a feature that is very adaptive because it allows us to give more weight to and better remember things that are *followed by* positive or negative consequences even if those consequences occur well after the event. Injection of certain drugs *following* learning enhances long-term (but not short-term memory), a process called retrograde memory enhancement. Retrograde memory enhancement is adaptive: if emotion follows learning, the brain says, "This is something worth remembering." (Retrograde memory enhancement has important implications for us as teachers, indicating the need to teach with emotion, including celebrations following accomplishments.) Recall is not unitary; it is a term used to refer to many complex and independent brain processes.

All Thinking Skills are Multi-Faceted. Just like there are many types of recall and various components to each type, so too are the other thinking skills multi-faceted. Let's take, for example, evaluation. If the connections are severed between brain structures associated with processing feelings and other parts of the brain, a person becomes incapable of feeling, and incapable of making up her/his mind. All alternatives appear equally attractive. The person can state the pros and cons of an issue very fully and rationally, but cannot decide among them. The clinical term for this is alexithymic.[18] What does this mean for the case for thinking skills as single entities? It is another blow. One facet of evaluation — the ability to state pros and cons of an issue— is perfectly intact whereas another facet of evaluation — ability to choose among alternatives— has been disabled. Evaluation is not one thing. Nor are any of the other thinking skills in Bloom's Taxonomy. As brain science progresses, it will become less and less meaningful to speak of each of the thinking skills as single entities, just as today it is no longer meaningful to speak of recall as one skill —it is many very discrete skills, each independent of the others.

Beyond Bloom

Brain research converges on a simple conclusion: There are many types of thinking and each type of thinking develops and functions relatively independently of the others. Given this, as educators, our mission becomes a bit more complex. We cannot develop just six types of thinking and feel we have left our students well prepared. For example, because deductive reasoning involves brain structures independent of probabilistic reasoning, we cannot foster in our students one type of logic skill and assume the other types have been developed. To prepare our students with a full range of thinking skills, we need to focus on a range of skills greater than those described in Bloom's Taxonomy.

How Do We Cut the Pie? There are many ways to cut the thinking skills pie. We have found an information processing approach to be very useful. This approach is attractive because, as described at the outset of this article, there has been an explosion of information and the ability to understand, manipulate, communicate, and generate information will be at a premium for the foreseeable future. Thus, we have divided thinking skills into three types: those primairly related to 1) understanding information; 2) transforming information; and 3) generating information, See Table 4. Within each category we have focused on five skills. There are clear limits to this approach. It does provide a completely comprehensive set of skills and skills do not fall entirely neatly into the three information-processing categorics. Further, although the approach is aligned with brain science in that it emphasizes discrete skills, it is not derived from brain science, and will need to be revised as brain research uncovers more about the types and nature of the discrete thinking skills. Nevertheless, the information-processing approach is a useful tool in organizing and defining a comprehensive thinking skills curriculum.

How Do We Deliver the Pie? There are many ways of fostering thinking skills, including lessons, activities, and instructional strategies. In our own work in this area, we have leaned heavily toward an instructional strategy approach. That is, rather than teaching lessons on thinking skills, we embed thinking skills into any lesson by using instructional strategies that engage those skills. Rather than teaching about the skills, we have students practice them. For example, during a lesson on democracy, the teacher may have students do a Team Statement. Working alone each student writes a definition, and then the students work together in a structured format to write a team definition. The content of the lesson is democracy, but in the process of dealing with that content the students are practicing synthesis level thinking — synthesizing one definition from the best elements of several. To take another example, to foster analytic thinking, the teacher may use Pairs Compare, in which pairs analyze the elements of something and then compare their findings with another pair. Team Statements and Pairs Compare are two of many instructional strategies designed to foster thinking.[19] Each strategy can be used with a very wide range of content at all grade levels. One advantage of the instructional strategy approach to thinking skills is that once the teacher learns to use the strategies on a regular basis, thinking skills become part of every lesson without special preparation or planning. Delivery of the thinking skills curriculum does not compete for time with delivery of the regular academic curriculum.

Table 4: Structures for Thinking

Structures for Thinking

THINKING SKILL	SYNONYMS & RELATED SKILLS	SAMPLE STRUCTURES
UNDERSTANDING		
1. Recalling	Drawing info into Working Memory, Memorizing, Paraphrasing, Recollecting	Flashcard Game (Semantic Memory); Boss-Secretary (Procedural Memory); Simulations (Episodic Memory) choose a chip
2. Summarizing	Abstracting, Comprehending, Describing, Observing, Processing	Three Step Interview; paraphrase passport Timed Pair Share
3. Symbolizing	Choreographing, Drawing, Illustrating, Translating, Verbalizing, Visualizing	Draw What I Say; Window Panning; Mind Mapping
4. Categorizing	Associating, Classifying, Grouping, Patterning, Rearranging, Sequencing, Sorting	Find A Frame; Fill A Frame similarity groups
5. Shifting Perspective	Empathizing, Visual/Spatial Perspective Taking	Paraphrase Passport
TRANSFORMING		
6. Analyzing	Decontextualizing, Disembedding, Dissecting, Dividing, Separating	Pairs Compare; Same Different
7. Applying	Adapting, Decontextualizing, Transferring	Team Pair Solo
8. Inducing	Example to Idea, Inferring, Observing, Hypothesis Generation and Testing	Find My Rule
9. Deducing	Deducting, Drawing Conclusions, Idea to Example, Reasoning	Logic Line-Ups
10. Calculating	Estimating, Solving, Applying, Checking	Pairs Check; RallyCoach
GENERATING		
11. Brainstorming	Creating, Elaborating, Exaggerating, Inventing, Reversing	4S Brainstorming; Jot Thoughts
12. Synthesizing	Associating, Blending, Building, Combining, Creating, Integrating	Team Statements
13. Predicting	Anticipating, Estimating, Extrapolating, Sequencing	Estimate Line-Ups
14. Evaluating	Assessing, Criticizing, Decision Making, Determine Fallacies, Interpreting, Prioritizing	Sum The Ranks; Agree-Disagree Line-Ups
15. Questioning	Hypothesizing, Inquiring, Investigating	Q-Matrix; Spin-N-Think choose a chip

Why Rethink Thinking?

It turns out that if we are to align our thinking about thinking with how the brain actually functions, we will have to give up the notion of a simple hierarchy of thinking. If we are to do the best for our students, to prepare them as fully as possible with the range of thinking skills, we need to advance our thinking beyond Bloom's Taxonomy and accept instead the existence of discrete thinking skills, each of which engages and develops different parts of the brain. Although many approaches are possible as we select the thinking skills to develop, an information processing approach is very promising because it aligns both to how the brain, an information processing organ, functions and to the needs of our students as they prepare to live and work in a world being shaped by an information explosion.

A brain-based, information-processing model of thinking pushes us as educators to provide a much more differentiated thinking skills curriculum than does a simple six level hierarchal model. If we know, for example, that there are several very different types of recall, we can help students develop the skills associated with each. We will have greater academic success if we understand from the outset the type of memory or thinking skills we are attempting to establish, choosing our instructional strategy accordingly. Mnemonics aid semantic memory; practice procedures aid procedural memory; linking emotion to incidents aids episodic memory. If we know that deductive reasoning is associated with developing some areas of the brain and probabilistic reasoning is associated with developing other areas of the brain, we will be sure to have students practice both types of reasoning. As we align our thinking about thinking with how the brain actually functions and the needs of students entering an information-based economy, we will better align our teaching with how the brain best learns and the needs of our students. In the process we will become more efficient educators and better equip our students with skills for success.

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