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Dr Spencer Kagan

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. 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 and 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. This view of thinking has its roots in the work of Benjamin Bloom and his associates. In 1956, they created Bloom's Taxonomy 2 which describes six types of thinking arranged in a hierarchy, supporting the notion that there are higher- and lower-level types of thinking. 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**. In this article, we examine the three assumptions of this hierarchy in turn, show why each is not supported, and discuss the need for educators to rethink thinking.

Bloom's Taxonomy

Six types of thinking are arranged from simple to complex, built on the assumption that the more complex or higher-level thinking skills are built on the simpler or lower-level thinking skills.

Table 1: Bloom's Taxonomy

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

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 at a higher-level than evaluation.[3] 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.**

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."*[4]

If higher-level thinking skills in Bloom's 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. Following surgery, 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 after the surgery.[5] 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. 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! 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!

Notion 2: 'Higher-level' skills are more complex than 'lower-level' skills
Bloom and his associates thought of 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…."*[6]

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 the 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 "Did you go shopping today?" We simply know the answer – yes or no – without conscious deliberation. There is no cognitive complexity involved when we respond to most "Do you like it?" questions – we just know the answer. 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: Memory is a place

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. 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. 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 – and each of these types of memory is associated with very different brain structures and processes.

In (Kagan's) work on memory, the acronym **SPEWS** helps us remember five distinct memory systems.[7]

Table 3: Memory systems and brain structures

	Memory system	**Associated brain structures**	**Recalling of…**
S	Semantic	Temporal lobe	facts
P	Procedural	Putamen	procedures
E	Episodic	Hippocampus and related structures	incidents
W	Working	Frontal lobe	thoughts we have just had
S	Spatial	Right hippocampus	getting from place to place

Beyond Bloom

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. 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 primarily 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 categories. Furthermore, 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.

Table 4: Structures for thinking

Structures for thinking

Thinking skill	Synonyms and related skills	Sample structures
UNDERSTANDING		
1. Recalling	Drawing information into working memory, memorizing, paraphrasing, recollecting	Flashcard Game (semantic memory); Sage-N-Scribe (procedural memory); Simulations (episodic memory)
2. Summarizing	Abstracting, comprehending, describing, observing, processing	Three-Step Interview; Timed Pair Share
3. Symbolizing	Choreographing, drawing, illustrating, translating, verbalizing, visualizing	Draw What I Write; Window Panning; Mind Mapping
4. Categorizing	Associating, classifying, grouping, patterning, rearranging, sequencing, sorting	Find-A-Frame; Fill-A-Frame
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. Deducting	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, determining fallacies, interpreting, prioritizing	Sum-the-Ranks; Agree-Disagree Line-Ups
15. Questioning	Hypothesizing, inquiring, investigating	Q-Matrix; Spin-N-Think

How Do We Deliver the Pie?

There are many ways of fostering thinking skills, including lessons, activities and instructional strategies. Rather than teaching about the skills, have students practice them. For example, during a lesson on working together, society or 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.[8] Each strategy can be used with a very wide range of content at all 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.

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 hierarchical 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.

References

1 Noah, T. *Why you can't keep up.* (***Chatterbox***, November 4, 2003. **http://slate.msn.com/id/2090756**.)

2 Bloom, B.S. (Ed.) ***Taxonomy of educational objectives: The classification of educational goals: Handbook I, Cognitive Domain***. New York: Longmans, 1956.

3 Anderson, L.W., & Krathwohl (Eds.) ***A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives***. New York: Longman, 2001.

4 Bloom, B.S. (Ed.) ***Taxonomy of educational objectives: The classification of educational goals: Handbook I, Cognitive Domain***. New York: Longmans, 1956, p. 120.

5 Hilts, P.J. *Memory's Ghost.* ***The Nature of Memory and the Strange Tale of Mr. M***. New York: Simon & Schuster, 1995.

6 Bloom, B.S. (Ed.) ***Taxonomy of educational objectives: The classification of educational goals: Handbook I, Cognitive Domain***. New York: Longmans, 1956, p. 18.

7 Kagan, M. & Kagan, S. *The Five Major Memory Systems SmartCard*.San Clemente, CA: Kagan Publishing, 2003.

8 Kagan, S. ***Cooperative Learning***. San Clemente, CA: Kagan Publishing, 1994.
Kagan, S. & Kagan, M. ***Multiple Intelligences: The Complete MI Book***. San Clemente, CA: Kagan Publishing, 1998.