Putting MB to Work

Fostering Learning and Community with Brain Research

When I (Andrew) plan professional development workshops with independent school leaders, I occasionally get this bottom-line question: "What is the single most important lesson that the brain sciences have for schools and teachers?"

To answer that question, I offer a three-step exercise:

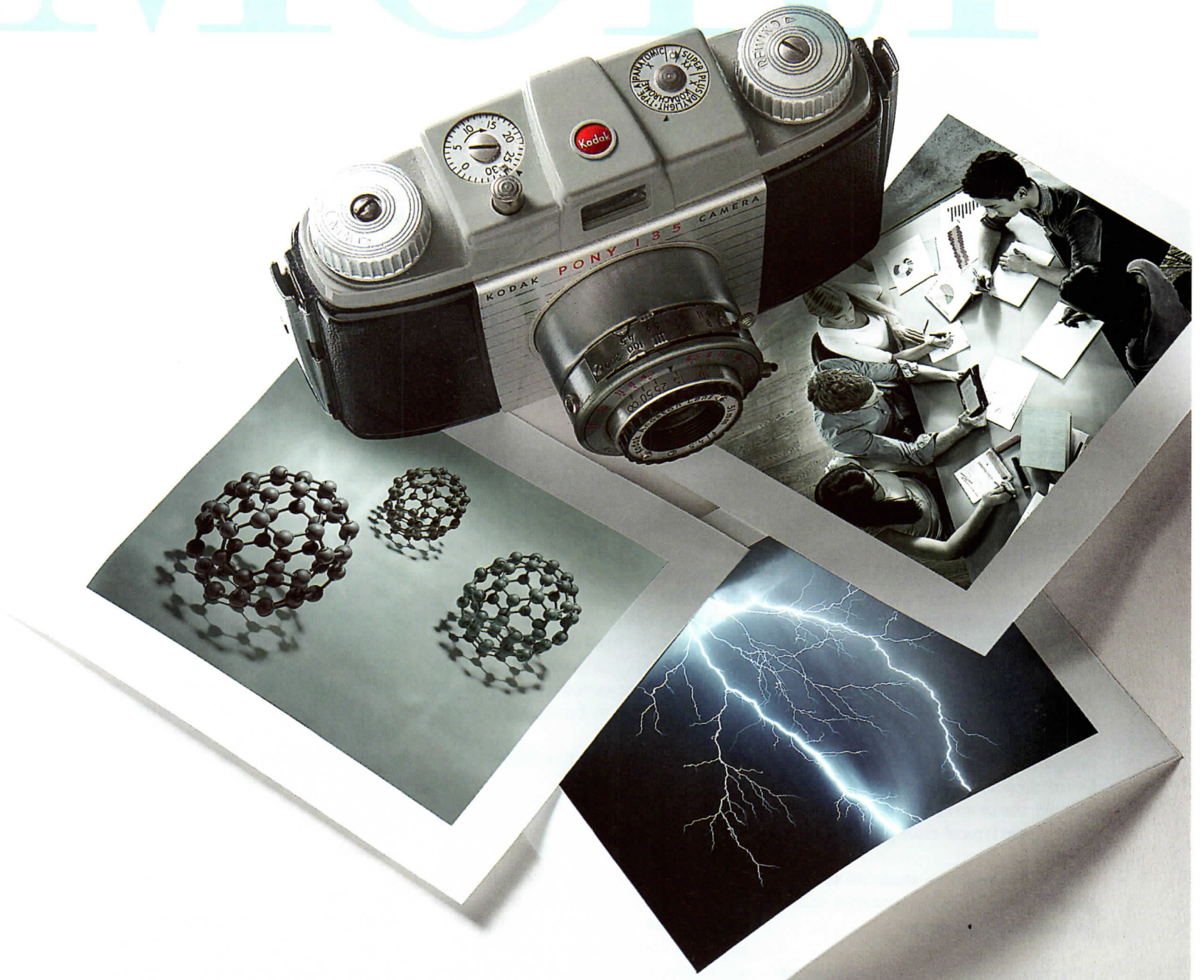
- **Step one:** Think of a 10-digit phone number that you know very well, and say those digits out loud. (Go ahead, say them.) Easy, right?

- **Step two:** Now say those 10 digits backward. (No, really, try it.) Not so easy, but — after some initial hesitation — most people can do this step fairly easily.

- **Step three:** Say the 10 digits backward again, but this time add 1 to the first digit, 2 to the second, 3 to the third, and so forth. (Push hard here: See if you can do this.) This task also feels difficult at first, but, unlike the previous step, it remains difficult despite sustained effort. In fact, very few people can accomplish it successfully.

BY ANDREW C. WATSON, MICHAEL WIRTZ, AND LYNETTE SUMPTER

MORY



CAMERA: MICHAEL NORTHRUP; MOLECULAR MODELS: MICHAEL NORTHRUP;
LIGHTNING: NANCY NEWELL/GETTY IMAGES; STUDENTS: VM/ISTOCK

These three steps reveal a remarkable truth about brains and learning, because the third step should not be all that difficult. After all, adding single-digit numbers is first-grade arithmetic. But that arithmetic becomes next to impossible when we must simultaneously remember and reverse a list of 10 digits. We simply run out of the cognitive space we need to perform these operations.

This exercise helps us answer the bottom-line question: "What is the most important lesson that the brain sciences have for schools?" The answer: Teachers must understand and actively manage their students' *working memory*.

A Beginner's Guide to Working Memory

What exactly is "working memory"? It is not "declarative memory" — that is, long-term memory of factual information. It is not "procedural memory" — that is, habit memory of how to do things. Instead, working memory allows us to hold on to a few pieces of information for several seconds, at best, and to reorganize them into a new system or structure.

Another example of working memory: To name the teachers in your department in alphabetical order, you have to remember who your colleagues are, how to spell their names, and the order of the alphabet. Then, you have to manipulate and reorganize that information to create the new mental list. This reorganization happens in your working memory.

How much time do students spend using their working memory in school? That is, what percentage of their day do they spend combining and reorganizing information from different sources? In most independent schools, the answer is: almost all of the time. Some typical examples:

- Geometry requires students to reorganize givens into the patterns called for by specific theorems.

- History requires students to reshape historical data into fresh conceptual patterns.

- To learn Spanish, students must add endings (depending on verb type) to verb stems.

- When subordinating a quotation in an English essay, or explaining the role of water in photosynthesis, or even deciding when to bunt in baseball, students recombine multiple concepts and pieces of information into a new pattern in their working memory.

Schools are, in effect, shrines built to honor successful working memory functioning. Students simply can't think and learn without using working memory all the time.

Yet this description of working memory reveals an important problem. When people try to add digits to their backward phone number, as noted, they're using their working memory. The reason most can't succeed in this task, however, is that human working memory capacity is surprisingly small. Consider that most people can easily alphabetize the names of five U.S. states, because five is a small enough number to manipulate in working memory. Alphabetizing 10 states, however, simply overwhelms working memory capacity — unless you know the song that lists the states in order.

To sum up the challenge for educators: Working memory is essential for academic learning, and yet people have surprisingly little working memory. (Occasionally, I'll joke that working memory is like a school's endowment: We absolutely need it, and we never have enough.) Clearly, this pair of truths about cognition explains many of the difficulties students face in our schools.

How Can Educators Manage Working Memory?

We (Andrew, Michael, and Lynette) had been teaching for many years before we seriously considered the impact of working memory limitations as we structured our classrooms and lessons. In truth, we paid little attention to a cognitive capacity that is essential for our students' learning. For this reason, we probably overwhelmed our students' working memory without ever realizing we had done so. But we also know that we are not alone. The lack of knowledge about the role of working memory in education is a typical problem among educators.

As teachers, what should we do? First, we should develop our own expertise in the field of working memory — understand what it is, how it differs from, and contributes to, long-term memory.

Second, we should explicitly discuss and develop teaching techniques to support our students' cognition within their limited working memory capacity.

In essence, we need to know *when* we might overwhelm our students' working memories, *how* students act when we do, and *how* to solve the problems that arise from working memory overload. Table 1 (on page 59) summarizes these categories, but it is helpful to focus on two sample strategies.

Solution 1: Make information visual.

Humans have much more brain real estate devoted to visual processing than to all our other senses combined. For example, in one study by Richard Mayer, professor of psychology at the University of California, Santa Barbara, students who saw annotated pictures explaining the formation of lightning did twice as well on a transfer test as students who read a simple description of the process. Visual depiction reduces working memory demands.

To make information visual, we can create flowcharts or diagrams; we can use photos or videos; or we can simply write down complicated instructions. After all, if students need to keep unwritten instructions in mind, those instructions take up working memory capacity, and thus paradoxically reduce students' capacity for thinking and learning.

Solution 2: Actively manage note taking.

If students are trying to understand an idea at the same time that they're writing notes, those two processes compete with each other in working

Table I:

What classroom/homework activities might overwhelm working memory capacity?
• Too much new information at once • Too many new combinations of information at once • Verbal instructions, especially long or complex instructions • Work combining cognitive and creative effort • Work early in the morning, or late at night
How do students react when working memory is overloaded?
• Difficulty remembering some information while processing other information (*e.g.*, long multiplication) • Atypical difficulties with attention • "Catastrophic failure": difficulty adding just one simple step to several previous steps
How to solve working memory difficulties
• Redistribute working memory demands across longer periods of time • Make information visual • "Chunking": organize material into an already familiar pattern • Teach strategies (*e.g.*, Treviso multiplication) • Explicitly connect new information to old information • Manage note taking • Reduce pressure from time, grades, and peers • Regularly emphasize that struggle is normal • Reduce attentional distractions in the classroom • Lower stress, especially with mindfulness • Promote attention by reducing distractors and reinforcing conceptual frameworks

memory. As a result, they're likely not to do either one very well.

The simplest version of this solution is to stop students from writing while we are explaining new, complex, or important ideas. Say to them: "Put your pencils down; I want you to listen and think for a moment.... " Once we have finished explaining the concept, they may start writing; however, while they write, we should not talk. Instead, we can circle the room and see what they are writing. This strategy ensures that students are not listening to us at the same time they're writing an idea down. It also allows us to see how well they understood that idea in the first place.

Many other strategies allow teachers to "manage note taking": using handouts, group notes, whiteboard snapshots, etc. The goal in all of them is to ensure that we are not overwhelming the students' working memories.

From Research to Classroom

While these specific strategies benefit students, scientific knowledge can benefit teachers. Once we have a baseline understanding of working memory, we can use it flexibly and powerfully in our own classrooms to boost the effectiveness of our teaching and the depth of student learning.

When we (Michael and Lynette) invited Andrew to address the faculty at St. Mark's School (Massachusetts), we saw how powerfully this scientific approach to learning shaped our teaching practices. Even skeptical faculty left this session feeling positive about the presentation and seeing value in the concrete classroom strategies. One mid-career teacher wrote us about her use of this knowledge:

> *I used to think that pushing the bounds of memory was helpful, much like how lifting weights makes you stronger in the long run. I learned it is quite the opposite for working memory, and that overtaxing it can cause our students to shut down. As a result, I have tried to provide more visual clues, word banks, fewer choices, etc., so that students focus on the most important task at hand, instead of trying to juggle too many pieces of information in their working memories.*

This teacher's varied strategies — presenting information visually, reducing extraneous choices that might overwhelm working memory, and guarding against "catastrophic failure" — show how flexibly and effectively she adapted the lessons of working memory to her teaching practice.

The framework of working memory also helps us do our work in academic leadership. During a recent class observation of a teacher, we watched her divide lab instructions with working memory limitations in mind. Rather than give all of the instructions for the activity at the beginning of class, she divided instructions into working memory–manageable chunks. Each group reported to its station, and, once there, received a few more steps to follow.

While this approach might seem to take needless time and create extra work — because the teacher has to give the same set of instructions repeatedly — it actually takes less time and reduces work because all the students followed the instructions correctly the first time. Our common working memory language allowed us to discuss this strategy with the teacher with welcome clarity and efficiency.

Three years ago, to highlight our emphasis on learning as a community, St. Mark's School developed a yearlong, in-house professional development program called Professional Learning Groups (PLGs). Recognizing the increasing complexity of educational research and practice, wanting to model intellectual growth and risk taking for our students, we reexamined our work in service of deeper student learning. For their PLGs, faculty members choose one topic to pursue over the entire school year — Diversity, Assessment, Adolescent Development, Academic Technology, or Mind Brain Education — and meet with these cross-departmental groups once a month for well-informed discussions. Over the course of five years,

they will have engaged in all five topics. Because the PLG topics include "Mind Brain Education" — that is, the combination of psychology, neuroscience, and pedagogy — this PLG program keeps our discussion of working memory lively, concrete, and rooted in classroom practice.

Because this focus on working memory has been so helpful to our faculty, we have also made it a part of our yearlong extended orientation for new faculty. Andrew facilitates sessions with each new cohort, so that the full faculty — regardless of start date — has the same background knowledge of working memory. New teachers appreciate this support and the sense of being brought up to speed with their colleagues in a small group setting. (In a few cases, returning faculty joined to brush up on the topics covered!)

One new teacher, noting the value of these sessions, stated, "I've learned about how small and essential working memory is. When planning my lessons, I'm much more intentional about looking for areas where I risk overwhelming working memory. I know what to look for during a lesson to see if students are reaching the point of overload and how to change things up to get them back on track."

Anecdotes such as this are frequently heard in conversations with faculty, both new and returning. In fact, as more faculty have cycled through the Mind Brain Education PLG and the new faculty sessions, conversations describing student learning have begun to change in our community. Teachers increasingly use language describing their work not as conveyors of content but as facilitators of learning. In doing so, they recognize when — and how often — they need to challenge long-held notions of effective pedagogy.

In all these gatherings — full faculty meetings, classroom visits, PLG meetings, extended new-faculty orientation — our faculty's deepening understanding of working memory has given us both a vital topic for discussion and a set of strategies with which to shape our discussions most effectively. By using strategies that reduce working memory load while presenting information about working memory, we have been able to ensure that this complex and essential field of knowledge has not gotten lost in the blur of one-time professional development presentations. Instead, it has become a steady and practical part of our teachers' long-term memories. As a result, we see improved teaching, deeper learning, and the flourishing of a community of Mind Brain Education–based scholarship.

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