THINKING MAPS®

The Building Blocks of Brain-Based Learning

The Research Base for Thinking Maps®

We are all learning things every day, whether we intend to or not. The brain is built to learn and remember. Understanding the *way* the brain learns and remembers is the key to optimizing the learning process for all students.

Thinking Maps are designed to activate cognitive processes that enable authentic learning. The Maps help students encode new ideas so that they can remember them effortlessly and make connections that support deep comprehension and critical and creative thinking. The key to their efficacy is how they tap into the way the brain learns naturally.

What Do We Mean When We Talk About Learning?

The brain is always changing itself as it learns and experiences new things. We call this process *neuroplasticity*. When we learn something new, we are literally changing the way that the brain is wired[1,2].

The human brain is made up of more than 100 billion neurons (brain cells)[3]. These neurons communicate at junctions called "synapses" using chemicals (neurotransmitters) and electrical signals. Neurons that fire together repeatedly produce strong connections that are the basis for the way the brain encodes and retrieves information. "Neurons that fire together wire together" is one of the foundational principles of brain research[4].

The stronger we can make that neural connection, the better we are able to remember what we have learned. Connecting our newly encoded memory to *other* things we know and have experienced is the basis for deep understanding and higher-order thinking[5].

Some of these neural connections are already hard-wired. The human brain has been shaped over millions of years of evolution to pay attention to some things and discount others[6]. We are naturally drawn to pay attention to and remember things that may be important for survival and well-being. Understanding and working with these natural hard-wired brain preferences will make learning more efficient, effective, and enjoyable.

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[1] Lamprecht, R., and LeDoux, J. (2004). "Structural Plasticity and Memory." *National Reviews Neuroscience* 5(1) 45-54. doi:10.1038/nrn1301

[2] Bermúdez-Rattoni, F. (2007). *Neural Plasticity and Memory: From Genes to Brain Imaging*. Boca Raton: CRC Press.

[3] Carter, R. (1999). *Mapping the Mind*. Berkeley: CA University of California Press.

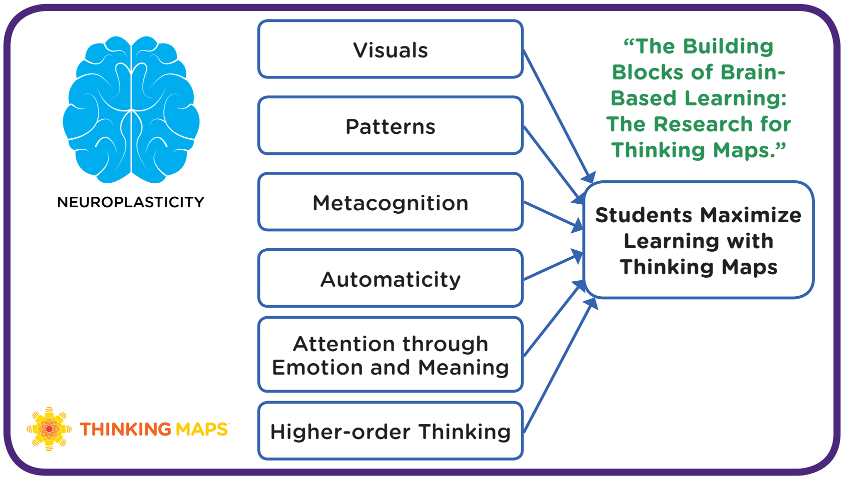
[4] Squire L and Kandel E. (1999). *Memory: From Mind to Molecules*. New York: Scientific American Library.

[5] Geinisman, Y., Berry, R. W., Disterhoft, J. F., Power, J. M., & Zee, E. A. (2001). Associative Learning Elicits the Formation of Multiple-Synapse Boutons. *The Journal of Neuroscience, 21(15)*, 5568-5573. doi:10.1523/jneurosci.21-15-05568.2001

[6] Ratey, J. J. (2002). A User's Guide to the Brain: Perception, *Attention and the Four Theaters of the Brain*. New York, NY: Vintage Books.

The Brain-Based Foundations for Thinking Maps

The Thinking Maps common visual language is built on decades of brain research that provides deep insight into both *how* new learning is encoded and *what* the brain likes to pay attention to. The principles of neuropsychology outlined below build on each other and work together to enable more effective learning.



1. Make it Visual

Our brains are built to prioritize visual information. The visual cortex, the part of the brain where visual information is processed, is the largest system in the human brain and is highly evolved to process complex information[7,8].

Visual information is processed differently than language; our brain is an "image processor," not a word processor[9]. Most bits of information are stored only in short-term memory and never make it to long-term memory storage—think of how much repetition is needed to remember a random string of numbers like a phone number, for example. But images are more likely to go to the long-term storage part of the brain[10], an effect known as the *picture superiority effect*. People are more likely to remember visual information, and remember it accurately, when tested for recognition later[11]. That's why visual cues are so valuable in helping us better retrieve and remember information.

Images can help us:

- Store and retrieve information more efficiently
- Make communication simpler and faster
- Comprehend, absorb, and analyze complex information

[7] Wolfe, J. M. (2006). *Sensation & Perception*. Sunderland, MA: Sinauer Associates.

[8] Note: in visually impaired people, the visual cortex is repurposed to process other types of sensory information, such as hearing and tactile information. When working with students blind from birth, teachers will need to use other sensory methods to tap into the processing power of the visual cortex (Hamzelou, J. (2017, September 18). Blind people repurpose the brain's visual areas for language. New Scientist. doi:10.1101/186338). Thinking Maps are available in braille for visually impaired students.

[9] Mcbride, D. M., & Dosher, B. A. (2002). A comparison of conscious and automatic memory processes for picture and word stimuli: A process dissociation analysis. *Consciousness and Cognition*, 11(3), 423-460. doi:10.1016/s1053-8100(02)00007-7

[10] Curran, T.; Doyle, J. (2011). "Picture superiority doubly dissociates the ERP correlates of recollection and familiarity". *Journal of Cognitive Neuroscience*. 23 (5): 1247–1262.

[11] Nickerson, R. S. (1968). A note on long-term recognition memory for pictorial material. *Psychonomic Science,* 11(2), 58-58. doi:10.3758/bf03330991

Thinking Maps make complex ideas visual to tap into the visual processing centers of the brain. It is a *visual language for learning*. When students put information into the Maps, they are activating the visual cortex to stimulate memory and understanding.

By combining words and images, the Maps take advantage of *dual coding*, using both the visual and the language processing parts of the brain at the same time. Dual coding strengthens memory by activating multiple parts of the brain[12].

2. Find the Pattern

In addition to liking visual information, our brains are primed to respond to patterns[13]. Random or chaotic information is likely to be meaningless. But *patterns* can be used to make sense of the world and make predictions about the future. Our brains look for patterns continuously—in the stars, in sports statistics, in the behavior of the people around us. For our ancestors, finding patterns in our environment was literally a matter of life and death, so it's no wonder our brains are wired to seek them out!

Engaging the pattern-seeking centers of the brain is essential for effective learning[14]. Patterns help us remember and assign meaning to information. They also make abstract ideas concrete and help us interpret complex information.

Thinking Maps provide a structure for learning and help students see patterns in information. Putting ideas into the form of a Map makes the pattern visual and concrete for students. Instead of trying to absorb and remember dozens of random facts, they are now able to see the "big picture" of how ideas fit together in a format that helps them understand and remember.

3. Connect to the Eight Core Cognitive Processes

There are a variety of ways in which we can display a pattern. However, to be most effective, these patterns should link to the fundamental cognitive processes that we engage in for learning. These processes, first defined by Albert Upton and later refined by David Hyerle[15,16], include Defining, Describing, Comparing and Contrasting, Classifying, Whole-to-Part Relationships, Sequencing, Cause and Effect, and Analogies and Relationships.

Tapping into these eight core processes allows students to move from simply acquiring facts to making meaning. They are the fundamental ways that we engage with and make sense of information. When students understand and are able to apply these modes of cognition, they are able to engage with and master virtually any kind of content.

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[12] Clark, J. M. & Paivio, A. (1991). Dual coding theory and education. *Educational Psychology Review*, 3(3), 149-170.

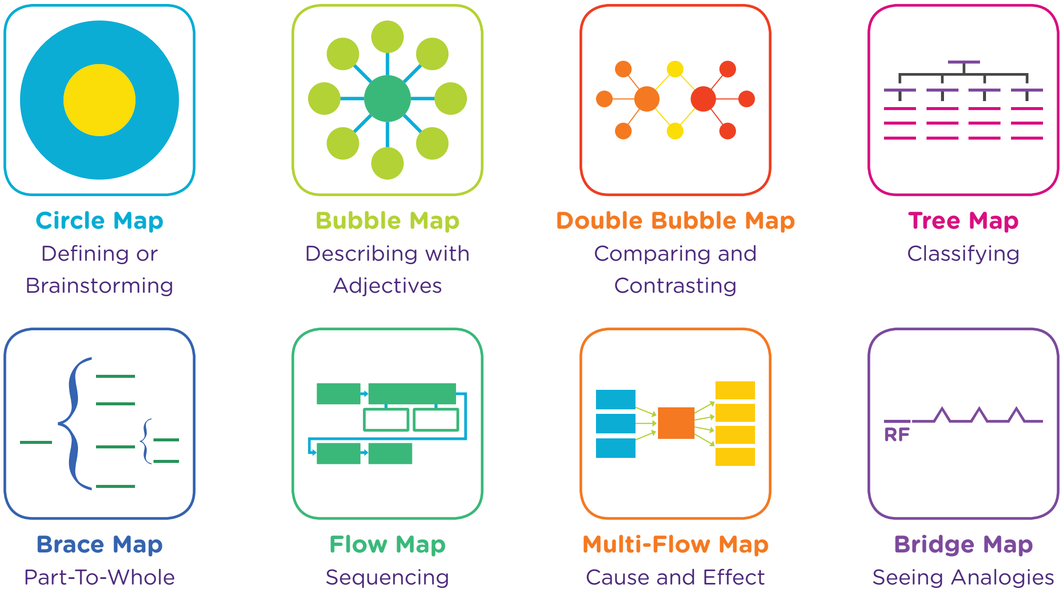
[13] Mattson, M. P. (2014). Superior pattern processing is the essence of the evolved human brain. *Frontiers in Neuroscience*, 8. doi:10.3389/fnins.2014.00265

[14] Barkman, R. C. (2000). Patterns, the Brain, and Learning. *Classroom Leadership*, 4(3).

[15] Upton, A. (1973). *Design for Thinking: A First Book in Semantics*. Palo Alto, CA: Pacific Books.

[16] Hyerle, D. and Yeager, C. (2017) *A Language for Learning 2nd Edition*. Cary, NC: Thinking Maps, Inc.

The eight Thinking Maps are aligned directly with the core cognitive processes. Using the Maps helps students make their thinking visible. As students learn how to select and use the right Map for a variety of tasks and information types, they become more aware of their own thinking processes. Using the Maps reinforces the patterns of effective learning so that students can transfer these thinking skills to any new subject or task.



One of the keys to using Thinking Maps effectively is helping students connect key academic vocabulary with the eight Maps and the thought processes that they represent. For example, students learn to recognize that words like “impact,” “consequences,” or “origin” are related to the core process of “cause and effect” and are visualized using a Multi-Flow Map. Building these connections helps students understand the purpose and structure of the content they are engaging with and quickly select the right Map to organize their thinking.

4. Build Automaticity

Automaticity is the ability to do something automatically and fluently without having to think about it on a conscious level[17,18]. We see automaticity at work when a student moves from having to sound out every syllable while reading to being able to read words fluently and focus on their meaning rather than the process of reading itself[19].

Automaticity is important in education because achieving fluency at lower-order tasks frees up cognitive room to concentrate on higher-order tasks. The struggling reader who is spending all their cognitive energy on decoding words does not have much space left over to engage with the big ideas in the book he or she is reading. As more mundane tasks become fluent and automatic for students, they are able to concentrate their energy on higher-order thinking[20].

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[17] Flor, R and Dooley, K. (1998). The dynamics of learning to automaticity. *Noetic Journal*, 1(2): 168–173.

[18] Gray, C. (2004). Understanding cognitive development: Automaticity and the early years child. *Child Care in Practice*, 10(1), 39-47. doi:10.1080/1357527042000188070

[19] Samuels, S. J., & Flor, R. F. (1997). The Importance Of Automaticity For Developing Expertise In Reading. *Reading & Writing Quarterly*, 13(2), 107-121. doi:10.1080/1057356970130202

[20] Martinez, M. E. (2006). What is Metacognition? *Phi Delta Kappan*, 87(9), 696 699. doi.org/10.1177/003172170608700916

This is why Thinking Maps are used across all grade levels and content areas. There are many different ways to display information visually; an online search for graphic organizers will turn up thousands of results. But students should not have to reinvent the wheel every time they want to analyze cause and effect or compare and contrast two concepts. When we continually ask students to change the way they use and display information, they are spending too much cognitive energy on the process of filling out the new graphic organizer and not enough on engaging with the content itself.

When Thinking Maps are used consistently across an entire school or district, students achieve fluency with using the Maps and, more importantly, with the cognitive processes behind them. They automatically know which Map to use when they hear certain key words in an assignment. Students who are proficient with Thinking Maps take ownership of these strategies and apply them fluently for all kinds of tasks, often using them to organize their thinking even if teachers have not assigned a Map officially. Transporting these strategies from grade to grade and class to class saves time and makes learning more efficient for both students and teachers.

5. Tap into Emotion and Meaning

The brain is optimized to pay attention to two things: emotion and meaning[21]. Again, this goes back to basic survival instincts. Our brain rewards us for paying attention to things that produce positive effects and emotions. We instinctually avoid engaging with things that have negative associations[22].

That means that emotion is critical to learning[23]. Caine and Caine[24] explain, "Emotion and cognition cannot be separated. Emotions are also crucial to memory because they facilitate the storage and recall of information."

For teachers, this means that creating an emotional climate that is conducive to learning is essential. Students' feelings and attitudes about learning will inevitably impact their ability to learn.

Thinking Maps help to create positive associations with learning by enabling *every* student to be successful. The Maps are student-owned, giving students a large amount of creative freedom. They are also highly adaptable to different learning styles and needs. Students of all ability levels are able to create a Map, though their Maps will not all look the same. For example, students with low levels of English proficiency or language-based learning disabilities may use more visual cues in creating their Maps, while other students may use more words. But all students are able to engage with the same content and achieve success in organizing information into a Map, at all levels. Achieving success in creating a Map builds student confidence and creates positive associations with learning.

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[21] Hur, J., Iordan, A. D., Dolcos, F., & Berenbaum, H. (2016). Emotional influences on perception and working memory. *Cognition and Emotion*, 31(6), 1294-1302. doi:10.1080/02699931.2016.1213703

[22] Sylwester, R. (1994, October). How Emotions Affect Learning. *Educational Leadership*, 52(2), 60-65.

[23] Immordino-Yang, M. H. (2016). Emotions, Learning, and the Brain: *Exploring the Educational Implications of Affective Neuroscience*. New York: W.W. Norton & Company.

[24] Caine, R. N., & Caine, G. (1990, October). Understanding a Brain-Based Approach to Teaching and Learning. *Educational Leadership*, 48(2), 66-70.

6. Stimulate Higher-Order Thinking

Ultimately, the goal of education is to teach students to engage in higher-order thinking, including critical and creative thinking. It is not enough for students to be able to recall and repeat a set of facts on demand. To prepare for the rigors of college and the workforce, students need to learn how to be effective learners and how to apply critical and creative thinking to new situations.

Most educators will be familiar with Bloom's Taxonomy[25]. Bloom and his collaborators developed a framework for understanding thinking that categorizes learning tasks in a hierarchy from the simplest (basic recall) to more complex (analyzing, evaluating, synthesizing). Over the years, researchers have refined and revised the basic framework[26], but the core idea remains the same: true mastery of a concept requires students to be able to apply, use, evaluate, and analyze ideas in a variety of ways.

Critical and creative thinking are important components of college and career readiness[27]. Our society is increasingly information-based; 21st century learners and employees are expected to be able to understand and analyze complex information and combine what they know in new ways to solve problems and develop novel ideas. To prepare for the jobs of tomorrow—many of which have not yet been invented or even conceptualized—today's students must have the thinking skills needed to be lifelong learners and creative thinkers and problem solvers.

Thinking Maps help students develop and access higher-order thinking skills. As students use the Maps, they are increasing their ability to analyze and evaluate information and combine ideas in new and creative ways. While creating an individual Map may seem like a simple task, the Maps are robust and flexible enough to support the kinds of thinking required in college and beyond. That's why many teachers and school administrators use the Maps beyond the classroom for their own planning, idea-generation, and collaboration. Maps can even be combined in different ways to support deep engagement with concepts using multiple levels of thinking.

COMBO #8

Combo #8 is about analyzing form and function. The form or parts of something are identified in the Brace Map. The Tree Map is used to collect details about each part. The Bridge Map is used to summarize the purpose of each part.

Finally the Multi-Flow Map is for hypothetical thinking. For example, "What if this part is _____? What effect would that have on the whole?"

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[25] Bloom, B.S. (Ed.). Engelhart, M.D., Furst, E.J., Hill, W.H., Krathwohl, D.R. (1956). *Taxonomy of Educational Objectives, Handbook I: The Cognitive Domain*. New York: David McKay Co Inc.

[26] Anderson, L.W., Krathwohl, D.R., Airasian, P.W., Cruikshank, K.A., Mayer, R.E., Pintrich, P.R., Raths, J., Wittrock, M.C. (2001). *A Taxonomy for Learning, Teaching, and Assessing: A revision of Bloom's Taxonomy of Educational Objectives*. New York: Pearson, Allyn & Bacon.

[27] Mishkind, A. (2014). *Overview: State Definitions of College and Career Readiness*. Washington, DC: American Institutes for Research, College and Career Readiness & Success Center.

Thinking Maps also stimulate higher-order thinking through the use of the Frame of Reference, comments added to the "frame" of the Map that provide additional context and help students think about their thinking. Students create the frame using guiding questions such as "how do I know this?" or "why is this information important?" to stimulate metacognition and promote self-regulation in learning.

Building a Brain-Based Classroom

Creating a brain-friendly learning environment requires more than simply applying a hodge-podge of "brain-based" learning strategies. Brain-based teaching and learning requires understanding how the brain works on a fundamental level and developing consistent, coordinated approaches to learning that tap into these core processes.

This is exactly what Thinking Maps are designed to do. They make thinking visible to students, so they can see what's going on "under the hood" in their own brains. The Maps, when used consistently and correctly, reinforce the cognitive skills required for effective learning and help students access those thinking processes on demand. As students achieve automaticity in using the Maps and the cognitive processes behind them, they unlock their ability to engage with new ideas and information in increasingly complex ways.

This is what makes Thinking Maps more than just another program or classroom strategy. Thinking Maps are fundamental to the way we all learn—a universal *Language for Learning*.