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Facilitating the Networking Brain and the Patterning Mind

Leonardo da Vinci's Principles for the Development of a Complete Mind

1. *Study the science of art.*
2. *Study the art of science.*
3. *Develop your senses— especially learn how to see.*
4. *Realize that everything connects to everything else.*

—Buzan, 1996, p. 26

The "mapping metaphor" offered in the last chapter effectively conveys the big-picture influence of visual tools for transforming isolated, static information into actively mapped knowledge. This chapter goes to the heart of the detailed, conclusive research base that documents how visual tools facilitate learners' capacities to move fluently from the internal, unconscious networking brain to the external, conscious patterning mind through visual representations of thinking. Leonardo da Vinci offers guidance for this chapter as we see that students need to study analytically (scientifically) and creatively (artistically) and to develop their senses, but especially to *see* and to realize how everything is connected. Maybe da Vinci gives us the best definition of visual tools! Brainstorming webs directly facilitate creativity, graphic organizers help in more analytical processes, while conceptual mapping offers a rich synthesis of creative, analytical, and connective conceptual processes.

We will look through multiple frames in this chapter to see how visual tools facilitate the dynamic, evolving, lifelong development of the neural networking brain and the schematic patterning mind through nonlinguistic and linguistic representations of mental models. Before we delve into the implications for the use of visual tools as they are seen through the lens of brain research, schema theory, multiple intelligences, emotional intelligences, and habits of mind, let's first look at the most relevant research to classroom practice: the use of *nonlinguistic representations* and the significant area within that research that shows the high degree of effectiveness of graphic organizers.

NONLINGUISTIC AND LINGUISTIC REPRESENTATIONS

In what has become a landmark research study cited in many journals and by word of mouth in many schools around the country—*Classroom Instruction That Works: Research-Based Strategies for Increasing Student Achievement*—Robert Marzano, Debra Pickering, and Jane Pollock identify nine strategies that directly impact student achievement (Marzano et al., 2001):

1. Identifying similarities and differences
2. Summarizing and note taking
3. Reinforcing effort
4. Homework and practice
5. Nonlinguistic representations
6. Cooperative learning
7. Setting objectives and providing feedback
8. Generating and testing hypotheses
9. Cues, questions, and advance organizers

The authors, with the Mid-continent Research for Education and Learning Institute (McREL), used a meta-analysis process for analyzing and synthesizing classroom-based research studies to make key generalizations about what works. (For a discussion of the meta-analysis process, which combines results from studies to find "average effects," refer to pp. 4–6 of their book.) One of the top nine instructional strategies they identified is nonlinguistic representations. Following is the authors' background theory and definition of this instructional strategy:

> Many psychologists adhere to what has been called the "dual-coding" theory of information storage. This theory postulates that knowledge is stored in two forms—a linguistic form and an imagery form. . . . The imagery mode of representation is referred to as a nonlinguistic representation. The more we use both systems of representation—linguistic and

> nonlinguistic—the better we are able to think about and recall knowledge. (p. 73)

This *integration and direct use by students* of linguistic and nonlinguistic forms is the essence of visual tools. Integrating drawings or pictures in a visual map along with words creates a rich mental bond within the brain and mind for remembering information. This bond is constructed by the learner and thus offers a process for conceptualizing and transforming information into a meaningful visual display of the knowledge base of the learner on paper or computer screen. The maps become an external memory for the brain and mirror for mental reflection and self-assessment for the learner.

The authors continue to both distinguish between linguistic and nonlinguistic forms and link the forms, as they represent a range of graphic organizers that represent how to effectively translate research and theory into classroom practice:

> Graphic organizers are perhaps the most common way to help students generate nonlinguistic representations. . . . Graphic organizers combine the linguistic mode in that they use words and phrases, and the nonlinguistic mode in that they use symbols and arrows to represent relationships. (p. 75)

The "symbols and arrows" and other graphic representations such as boxes, ovals, and lines used for linking information in brainstorming webs, graphic organizers, and concept mapping may be the macroscale visual links shown on paper that mirror the microscale *neural* connections the brain is making. The isolated words held in the web of a visual map—the vocabulary we wish students to acquire related to content knowledge—are the bits of distributed information that the brain is connecting together from across its neural pathways. As Pat Wolfe says, "One of the most important things we have learned is that the brain is primarily visual. . . . The brain does not outline. You form networks or maps of neurons and information is held within these maps" (Wolfe, 2006). The traditional linear outlines and linear sentences and paragraphs found on a "wall of text" are not representative of how the brain stores and links information. Visual tools are much more attuned to the natural networking of the brain, as we shall see in more depth in the following sections, and this is one of the reasons why linguistic/nonlinguistic visual tools work in classrooms.

Authors Marzano and Pickering extended their research on these nine strategies, with particular emphasis on graphic organizers, into an approach to *Building Academic Vocabulary* (Marzano & Pickering, 2005). What is of particular interest here is that the authors propose six instructional steps for typical classrooms that includes nonlinguistic representations as a key, including an adapted sequence for second-language learners. The reason for emphasizing visual tools in this sequence may be that, as we see throughout this book, visual tools are so supportive of and easily integrated with many of the other eight strategies that work. The authors refer to several visual tools, including the explicit use of several graphics that form Thinking Maps as a common visual language for learning (see Chapters 7 and 8).

For example, the strategy of "comparing and contrasting" is most easily accomplished by students when they graphically detail similarities of and differences between two concepts rather than only verbalizing their thinking. Marzano and Pickering suggest that the Thinking Map called the "Double-Bubble Map" is an effective tool for this process. Consider that it is very difficult for students to generate, organize, synthesize, and then evaluate all the information required for a comparison while holding this information in short-term memory or attempting to scan a page of linearly organized notes. They never transform the information into active and accessible knowledge. This is particularly important when students are using another of the nine strategies, *cooperative learning*. Students in cooperative groups—or adults working together in collaborative groups—need to be able to pull together the thinking of the group as a product that also represents their process. So often, the wide-ranging and rich patterns of learning generated during cooperative interactions are lost in the experience of the group and not represented in a form that really honors the depth of the group's thinking and conceptual growth. Oftentimes these rich patterns are just noted as static information in linear-list form. They are not *transformed* from bits of static information into rich, active patterns of knowledge.

This holds true for another of the nine effective strategies, "summarizing," as students are asked to summarize and to take notes from linear text. Often what students end up doing, without a visual tool, is merely to copy down ideas in static linear form even though the information is, for example, hierarchical, causal, or comparative in *form*. They have not *transformed* the in*form*ation into rich patterns of knowledge. They then do not internalize this *static* information as *active* knowledge but instead as a disconnected list. What *does not* show up in students' notes is their thinking patterns and processes of active knowledge. Additionally, as related to the nine strategies, visual tools offer "advanced organizers" or "cues" for beginning a lesson related to "setting objectives": when the teacher draws out a visual representation on a chalkboard or projected image on a screen, then students *see* the structure of thinking they are going to be asked to per*form* to most effectively meet a standard or objective. Obviously, my wordplay with the root "form" is important for understanding the power of visual tools related to learning: if we believe that learning is in the minds of the students, then they must be empowered to transform information into active, meaningful knowledge and deeper learning.

RESEARCH STUDIES ON GRAPHIC ORGANIZERS

The meta-analysis conducted by the McCREL authors identifies nine effective instructional strategies and is derived from reviewing research across a wide array of educational research designs and topics. When we look closely at the specific research on graphic organizers, it becomes obvious why these tools surface in the Marzano, Pickering, and Pollock study. A study recently released by the Institute for the Advancement of Research in Education (IARE) was generated from an analysis of 29 scientifically based research studies using academic databases to locate research on the instructional effectiveness of graphic organizers. Using the definitions set forth by Section 9101 of the No Child Left Behind Act (NCLB) of 2001, IARE selected studies that applied "rigorous, systematic, and objective procedures to obtain reliable and valid knowledge relevant to education activities and programs." The resulting summary that is excerpted below shows conclusively that *visual learning strategies improve student performance.*

The scientifically based research cited in the literature review demonstrates that a research base exists to support the use of graphic organizers for improving student learning and performance across grade levels, with diverse students, and in a broad range of content areas. IARE conclusions, taken verbatim from this review include the following:

Reading comprehension. Use of graphic organizers is effective in improving students' reading comprehension.

Student achievement. Students using graphic organizers show achievement benefits across content areas and grade levels. Achievement benefits are also seen with students with learning disabilities.

Thinking and learning skills. The process of developing and using a graphic organizer enhances skills such as developing and organizing ideas, seeing relationships, and categorizing concepts.

Retention. Use of graphic organizers aids students in retention and recall of information.

Cognitive learning theory. The use of graphic organizers supports implementation of cognitive learning theories: dual coding theory, schema theory, and cognitive load theory.

The evidence offered in this research and throughout this book shows that the outcomes with the use of graphic organizers include retention and recall of basic information as well as facilitation of conceptual development and higher-order thinking. The analysis showed that visual tools help students across a range of processes required in classrooms. Here is an (unorganized) summary list detailed in the study:

- Brainstorm ideas
- Develop, organize, and communicate ideas
- See connections, patterns, and relationships
- Assess and share prior knowledge
- Develop vocabulary
- Outline for writing process activities
- Highlight important ideas
- Classify or categorize concepts, ideas, and information
- Comprehend the events in a story or book
- Improve social interaction between students, and facilitate group work and collaboration among peers
- Guide review and study
- Improve reading comprehension skills and strategies
- Facilitate recall and retention

It is interesting to note the wide range of effects on student performance from these studies. Unfortunately, because the term *graphic organizer* has become common and ubiquitous, many educators assume that the use of linguistic/nonlinguistic graphics are constrained to the analytical processes under the heading "organize." The wide range of types of visual tools in this book attests to the flexible uses of these forms beyond supporting only the organization of information. Although it is true that most visual tools support organizational processes to some degree, many tools, as the research shows, are used for generative brainstorming, comprehension, synthesis, and evaluation as well as communication of ideas in classrooms.

READING COMPREHENSION AND READING FIRST RESEARCH

Instruction supporting early reading comprehension is now perceived as crucial to all learning and so it is essential that we go one step deeper into the research, beyond broad instructional strategies as defined by Marzano et al., and specific research on graphic organizers. In a document that was widely distributed by the U.S. Department of Education, *Put Reading First* (Armbruster et al., 2001), the use of graphic organizers is established as a central strategy for text comprehension. Developed by the Center for Improvement of Early Reading Achievement, this publication focused on five areas of early reading instruction: phonemic awareness, phonics, fluency, vocabulary, and text comprehension. Although debate on *the degree* of focus on phonics has intensified, the report's section on text comprehension meshes with the two meta-analysis studies reviewed earlier. Graphic organizers and a range of semantic maps are identified as central to reading text comprehension:

> Graphic organizers illustrate concepts and interrelationships among concepts in a text, using diagrams or other pictorial devices, . . . and can help readers focus on concepts and how they are related to other concepts. Graphic organizers help students to learn from informational text in the content areas, such as science and social studies textbooks and trade books. Used with informational text, graphic organizers can help students see how concepts fit common text structures. Graphic organizers are also used with narrative text, or stories, as story maps.
>
> Graphic organizers can:
>
> Help students focus on text structure as they read;
>
> Provide students with tools they can use to examine and visually represent relationships in a text; and
>
> Help students write well organized summaries of a text. (Armbruster et al., 2001, pp. 50–51)

If we look at the three meta-analyses reviewed previously—*Classroom Instruction That Works*, specific graphic organizer research, and the *Put Reading First* publication—a clear picture emerges: visual tools are concrete tools that enable all students to visually organize information, generate ideas and summaries of what they are reading and learning, and transform information into *active forms of* knowledge beyond the traditional linear structures teachers most often use.

Visual tools also offer graphic structures for content vocabulary development as well as visual bridges from basic information to improved thinking, metacognition, and self-monitoring practices by students. The *Put Reading First* document states that "metacognition can be defined as 'thinking about thinking.' Good readers use metacognitive strategies to think about and have control over their reading. . . . Comprehension monitoring, a critical part of metacognition, has received a great deal of attention in the reading research" (p. 49). So, despite the recurring "reading wars" that produce battle lines and philosophical/political swings between phonics-centered and meaning-centered activity at the early grades, *visual tools* provide a foundational bridge between the two. Visual tools, used with care, coherence, and deliberation, support content-specific vocabulary development *and* concept development. The capacity of our students to use visual tools for seeking isolated definitions in context while also consciously seeking the form in text structures across whole passages and books takes the learner to a higher-order level of understanding and awareness.

Although all of this research is crucial to a new level of awareness of the implications for using visual tools, let's contextualize this discussion by stepping back from specific classroom instruction and student-centered strategies to look at the broader context of educational research. Given what the detailed research shows about the processes of teaching, learning, and reading comprehension, let's consider the following questions:

> How are visual tools supported by research across wider fields beyond education?
>
> How do our brains and minds interact in this world to generate, remember, organize, and make sense of the information we take in from our body?

As we shall see, the links between the research on mapping information in classrooms for tasks such as vocabulary development, reading comprehension, and writing—across all content areas—dovetails with what we know about how the brain-mind-body system works in the "natural" world.

MAPPING LIVING SYSTEMS

Though obvious, it is important to recognize that the brain, mind, and body thrive within the natural systems that influence how we come to be human. Shifts in scientific theories of the structures and processes of life systems, brain research, schema theory of the mind, and intelligences all frame what is now becoming much clearer in educational practice: the use of visual tools for visual patterning and thus transforming information into knowledge may have a far greater impact on student learning than any other set of tools. It is very easy for us as educators to focus on the refined research in areas such as ever-expanding brain research, intelligences, cognition, and even reading comprehension without even starting with the world in which we swim, or *living systems*. A brief discussion of new theories of living systems may give us a wider context for seeing why visual tools are needed in the midst of shifting scientific paradigms for perceiving and understanding the world around us.

Over the past 50 years, a dramatic shift has occurred in the scientific and philosophical underpinnings of our understandings of life forms. In *The Web of Life* (Capra, 1996), Fritjof Capra brings together quantum physics, information theory, systems thinking, and theories linking the brain, mind, and cognition into a viewpoint of life processes. Briefly, Capra defines a living system as a system that "has a *pattern of organization* that is physically structured and activated by a life process that embodies these" (Capra, 1996, p. 161). The key characteristic of this definition of a living system is the *pattern of organization* of an organism and how we make sense of these patterns. Capra states:

> In the study of structure we measure and weigh things. Patterns, however, cannot be measured or weighed; they must be mapped. To understand a pattern we must map a configuration of relationships. (p. 81)

This underlying principle is what is now guiding brain researchers and educational leaders to use tools and techniques that support students in seeking, constructing, and, ultimately, understanding the *patterns* of information that ground every discipline we teach, and that support connecting all disciplines together. I believe that visual tools may have surfaced as tools for learning directly out of the need at this time in history to cope with a fundamental shift in our understanding of life systems. In times gone by, we were plenty satisfied by linear text and spoken language alone because these are primarily representation systems for expressing and coding a linear, structural understanding of the world.

If a new paradigm for understanding life forms is based on a dynamic systems view, rather than a mechanistic view of life, then tools that help us schematically *map* these networks become paramount. Of course, our perceptions of the natural world also influence our present conceptions of the human brain.

"Mind is not a thing but a process—the process of cognition, which is identified with the process of life. The brain is a specific structure through which this process operates. The relationship between mind and brain, therefore, is one between process and structure" (Capra, 1996, p. 175).

As we will see in the remainder of this book, a rich array of visual tools provides a way for students to discover what they know as they creatively weave static bits and linear strands of information from paper texts and electronic screens into active, meaningful knowledge. Students are seeking patterns in nature and in their neighborhood. Their brains are actively detecting patterns, and through a range of habits of mind and their multiplicity of "intelligences," they are organizing the raw data into schemata and attempting to surface these relationships. They are inductively generating new mental models of knowledge as networks of interconnected information.

"Maps are frames of reference. In them, a student must find a way to relate new information to other information. . . . Teachers often have not been exposed to creative map-teaching models or forfeit map learning to accommodate the mandate for higher test scores" (Caine & Caine, 1994, p. 46).

THE BRAIN IS A PATTERN DETECTOR

If we believe nature exists as patterns, then it is no wonder that the experts in brain-based learning all agree on one thing: the brain makes sense of the world by *constructing or mapping* patterns of the world. The focus on "patterning" is thus the entry point to understanding the connection between brain functioning and visual tools:

> The overwhelming need of learners is for meaningfulness. . . . We do not come to understand a subject or master a skill by sticking bits of information to each other. Understanding a subject results from perceiving relationships.

> The brain is designed as a pattern detector. Our function as educators is to provide students with the sorts of experiences that enable them to perceive "the patterns that connect." (Caine & Caine, 1994, p. 7)

The array of linked patterns in the brain is *always* more complex than the linear form in which we normally communicate these ideas in classrooms. Too often, students are returning to us linear lists of information or quick responses without having to organize the information into patterns. Or, they do *all* of this patterning in their mind without the memory capacity to fully *see* the patterns. Unlike the repetitive listing of information so often found in textbooks and classrooms, the brain is unconsciously reconstructing bits, shreds, and strands of related information from all over its physical frame while integrating sensory inputs into a multitude of overlapping patterns. As educators, we know that students have much more going on "in there" than we "get out" of them. Why? Many say that the brain is being underutilized. Less obvious is that what is actually "going on in there" has few pathways for "getting out of there" other than on the lined paper of schooled, linear representations. The brain's structural capacity for constructing patterns and the mind's cognitive processing capacity for expressing complex interrelationships in networks of knowledge is being dramatically underrepresented in linear strings of words, numbers, and other traditional symbol systems.

For example, when we ask students complex, higher-order questions, we are activating an unbelievable network of patterned firings of neural networks in the brain. But then we ask them to answer in linear terms: verbally, in writing, or by strings of numbers on the page. Often, many students respond by looking dumbfounded. Could it be that they do not have the tools to think and express their ideas holistically? Or is it that their rapidly patterned ideas are being condensed into short answers and exclusively in linear terms? The true mismatch is between the brain's capacity to pattern and the weak representation systems we provide students to represent their thinking. This situation creates an overload, or overly stressed cognitive load.

> "Visual tools are effective as learning aids. I want to find out what others have learned and how they connect it to prior learning. One end-of-course strategy is to cover a wall with flip chart or butcher paper. Then let small teams design a huge visual representation of what was learned. Either they can cooperate to create a synergistic visual map, or they can split up the content and each team makes their material as part of the whole. When it's done, it's a mural that creates common, unifying thinking—and it opens up new possibilities where gaps exist or connections are open" (E. Jensen, personal communication, August 1998).

THE VISUAL BRAIN

The mismatch stated in the preceding section is apparent because of the brain's structure. Remarkably, unbelievably, the brain is capable of absorbing 36,000 visual images every hour. How can this imponderable ability be true? It is because the sophisticated visual capacity of our brain system is beyond the conscious processing of our mind: research approximates that between 70 and 90% of the information received by the brain is through visual channels. Though our auditory and kinesthetic modes of "sensing" are complex, the brain's *dominant* and most efficient sensory filter for most information is our eyes. As Pat Wolfe states, "The brain is dominantly visual," partially because of the survival mechanism that was developed and evolved: we must remember what we see to survive. In a dramatic reversal of the view of many educators that auditory, visual, and kinesthetic approaches to teaching and learning must be balanced, we now know that the human brain has evolved into an *imbalanced* visual-spatial imager/processor. As Sylwester (1995) describes:

> The site of 70 percent of our body's sensory receptors, our eyes begin the cognitive process of transforming reflected light into a mental image of the objects that reflected the light. Light rays (photons) enter an eye through the system of the cornea, iris, and lens, which focuses the image on the thin retina sheet at the rear of the eyeball. The rays are absorbed by the retina's 120 million rods and 7 million cones, with each rod or cone focusing on a small, specific segment of the visual field. (p. 61)

Though most memory is constructed from activations all over the brain and all modalities must be reinforced, the brain has been evolving over time toward visual dominance. Even if we each believe that we are strongly "kinesthetic" or "auditory" or "visual," consider that each of us is still taking in *much* more information "visually" than through other modalities. We need to understand, and thus teach and learn with, this imbalanced strength in mind: most of our students and most of us, as we read this page, are strong visual learners.

"The impact of visualization on memory and recall has been demonstrated in numerous studies. In one, subjects were shown as many as 10,000 pictures, and then later shown some of these same pictures along with other pictures they had not seen. Under these conditions, they were able to recognize more than 90 percent of the pictures they had already seen" (Standing, 1973).

"It appears that not only are visual tools extremely effective in assisting students to initially process and make sense out of abstract information, they are also taking advantage of our brain's almost unlimited capacity for images" (Wolfe & Sorgen, 1990, p. 8).

Current brain research has provided many insights into how the brain unconsciously takes in and simultaneously and consciously processes information. Pat Wolfe represents three major stages of information processing within the dynamic system of the brain: paying attention, building meaning, and extending meaning (Wolfe & Sorgen, 1990). Most visual tools provide flexible cognitive patterns to students and teachers that are congruent with and facilitate each of these stages.

"The one million fibers in the optic nerve of each eye carry a summary of the vast amount of data that the [retina's] 127 million rods and cones receive. . . . Further processing (forward in the cortex) combines line segments into shapes, colors them, combines them, locates them in space, names them, and contemplates their meanings. At this point, sensory processes are being transformed into thought processes" (Sylwester, 1995, pp. 61–62).

THE MIND ORGANIZES INTO SCHEMATIC PATTERNS

The tantalizing details of recent brain research supports decades of cognitive science research drawn from behavioral studies focused on the mind at work. The dovetailing of brain and cognitive science research is grist for many books, but one of the most important links is between the networking structure of the brain and the "schematic" processing of the mind. Schema theory—which has been used as a foundation for brain research—brings the networking structure of the brain and the schema-generating mind together. The physical structure and actions of the brain are networking information, physically chunking and storing bits of information in certain regions. When these are "called up" from all over the brain, these isolated bits are integrated.

On a micro level, this integration supports the moment-to-moment, instinctual, unconscious, and repetitive processes of life. When larger chunks are called up to a more conscious level, the process of building or constructing cognitive structures from experience occurs. Schemas are not patterns available to the conscious human mind, but the building blocks of cognition and conscious mental modeling. As Daniel Goleman pointed out in his first book over 20 years ago, schemas are the transitional, ghostlike forms that carry raw experience to an organizational level:

> The packets that organize information and make sense of experience are "schemas," the building blocks of cognition. Schemas embody the rules and categories that order raw experience into coherent meaning. All knowledge and experience is packaged in schemas. Schemas are the ghost in the machine, the intelligence that guides information as it flows through the mind. (Goleman, 1985, p. 75)

Goleman's early work linked brain research with cognitive science and the beginnings of the concept of emotional intelligence in the book *Vital Lies, Simple Truths: The Psychology of Self-Deception* (1985). Here he shows the connection between brain research on attention and research on schemas:

> Schemas and attention interact in an intricate dance. Active attention arouses relevant schemas; schemas in turn guide the focus of attention. The vast repertoire of schemas lies dormant in memory, quiescent until activated by attention. Once active, they determine what aspects of the situation attention will track. . . . They also determine what we do not notice. It is here where the structure of brain and the processes of mind unite: the neural networking as a growing structure and the mindful attention and/or inattention to the organization of experiences. (Goleman, 1985, pp. 79–89)

Because schemas are often but not exclusively networks of categories, visual tools may complement a range of structural patterns of neural networks and schematic structures of concepts. Piaget and many others since have conferred great importance on the capacity of a learner to assimilate and accommodate new information and concepts into a previously held schema. The mental schema and the actual neural, *physical* structure of the brain then shift and re*form* into a new structure. If schemas are the bridge between the structure of the brain and the processing mind, visual tools may be a bridge between the patterning mind and the outward representation of the *form of thinking*.

MULTIPLE INTELLIGENCES AS ACTIVE PATTERNS

When we understand the brain as a pattern detector, we begin to see that the intelligences described by Howard Gardner are really about how the multiplicity of patterns is expressed—or represented in different ways. The eight intelligences (and possibly a ninth) are then more easily understood as different ways of re-presenting knowledge. In Gardner's fascinating early book on cognitive science, *The Mind's New Science*, he brings forth the idea that this new science traffics in representations:

> The cognitive scientist rests his discipline on the assumption that, for scientific purposes, human cognitive activity must be described in terms of symbols, schemas, images, ideas, and other forms of mental representations. (Gardner, 1985, p. 39)

Symbols and symbol systems thus are the translators or medium of the brain-mind-body connection into the realm of intrapersonal and interpersonal communications. What Gardner has done is ask us as an educational community—and as a larger community encompassing work, family, and personal leisure time—to expand our awareness and appreciation of different representation systems. The full expression is in products of mind:

> Symbols and symbol systems gain their greatest utility as they enter into the fashioning of full-fledged symbolic products: stories and sonnets, plays and poetry, mathematical proofs and problem solutions, rituals and reviews. (Gardner, 1985, p. 301)

Here we can make some correlations between the eight intelligences (representation systems) and visual tools. Linguistic, logical-mathematical, visual-spatial, interpersonal, and intrapersonal intelligences are directly supported by brainstorming webs, graphic organizers, and conceptual maps. These visual symbols support the construction of networks of language and logical processing and are based on a spatial patterning of information. These tools also provide a means of communicating frames of mind, perspectives, emotional patterns, and mental models among people. These visual maps become mirrors of the mind at work, thus facilitating an internal dialogue and self-assessment. Most important, visual tools act as *synthesizers of ideas* from across the multiplicity of intelligences.

Yet something deeper is at hand with visual tools than surface-level links to various intelligences: the brain-mind is a structure-process organism that detects and constructs patterns, and visual tools are foundational for sensing, thinking, and feeling across all these intelligences. Interpersonal and intrapersonal intelligences and communication are frames for action and emotional-intellectual responses in the world. As basic patterning tools, visual tools support learners as they seek patterns across all symbolic systems, since these symbolic systems are bound up in schemas. As Daniel Goleman (1985) points out,

> Schemas are intelligence in action. They guide the analysis of sensory input. . . . Schemas determine which focus attention seeks, and hence what will enter awareness. When driven by emotions like anxiety, schemas impose themselves with special force. (pp. 82–83)

Given these overlapping views, I am suggesting that what integrates different intelligences, and what also makes them distinct, is the brain-mind schemas, or webs of relationships, patterns, and interdependence.

HABITS OF MIND

So how do we understand and respond "intelligently" to the patterns that are before us? How do our habits of mind attend to all these patterns that the brain has detected and the mind has organized?

Capra and many critics of Western philosophy and education point out that the traditional paradigm for studying living systems has been based primarily on the study of structures; therefore, our educational system has as well. Translated into classroom life, students have been asked, "What are the parts?" rather than "How do all these parts work interactively together in a system?" We are beginning to shift from asking students to regurgitate discrete parts of topics toward a different way of perceiving the world—one requiring that they show *how* these discrete parts integrate into dynamic patterns. The idea of seeing the interconnected nature of things in the world is not new, but the idea that we need a representation system of visual tools outside of our existing forms is.

Educators are now shifting toward more process questions, and with this shift from the study of structures to an integrated study of patterns and processes, we will also change or add to our basic tools for understanding, constructing, and communicating knowledge. In a sense, we are in a transitional time of habituating our students to thinking in patterns.

How our minds respond to stimuli is bound up by the storehouse of overlapping, interconnected schema, yet our minds are not passive, and we make decisions—often unconsciously—about how we respond. These decisions are guided by habits of mind fully described and researched by Dr. Arthur Costa. Consider a few of these behaviors and habits of mind:

- Are we *impulsive* when confronted with an overload of information?
- Are we *empathic* when listening to another point of view?
- Are we *flexible* when we are in unfamiliar contexts?
- Are we *systematic* when working through a problem?

These habits of mind are among 16 Costa identified, which are used as an explicit framework in classrooms and across whole schools by students, teachers, and administrators as powerful facilitators of thinking.

- Persisting
- Managing impulsivity
- Listening with understanding and empathy
- Thinking flexibly
- Thinking about thinking (metacognition)

- Striving for accuracy
- Questioning and posing problems
- Applying past knowledge to new situations
- Thinking and communicating with clarity and precision
- Gathering data through all senses
- Creating, imaging, innovating
- Responding with wonderment and awe
- Taking responsible risks
- Finding humor
- Thinking interdependently
- Remaining open to continuous learning

Art Costa and Bena Kallick, in *Activating and Engaging Habits of Mind* (2000), offer this guidance as we consider the importance of facilitating mindfulness:

> In teaching for the habits of mind, we are interested in not only how many answers students know but also how students behave when they don't know an answer. We are interested in observing how students produce knowledge rather than how they merely reproduce it. A critical attribute of intelligent human beings is not only having information but also knowing how to act on it. By definition, a problem is any stimulus, question, task, phenomenon, or discrepancy, the explanation for which is not immediately known. Intelligent behavior is performed in response to such questions and problems. Thus, we are interested in focusing on student performance under those challenging conditions—dichotomies, dilemmas, paradoxes, ambiguities and enigmas—that demand strategic reasoning, insightfulness, perseverance, creativity and craftsmanship to resolve them. (p. xv)

This vision and the 16 habits of mind are often facilitated when visual tools are in practice. It is also clear that different types of visual tools—with varying purposes and outcomes—actively facilitate and trigger different habits of mind through the design and use of the tools. As we look at classroom practices of each type of visual tool—brainstorming webs, graphic organizers, and conceptual mapping—it becomes clear that there is a general correlation between each type of visual tool and clusters of habits of mind. (For a more detailed description, see Hyerle in Costa & Kallick, in press.)

Generally speaking and through specific examples shown in the following chapters, I have found that brainstorming webs focus more on the facilitation of creative thinking, graphic organizers on analytical thinking, and conceptual mapping on a synthesis of creative and analytical thinking while also directly framed by a metacognitive stance. Figure 2.1 shows these relationships in three categories I have created in a Tree Map. This view of the 16 habits of mind, as related to visual tools, is certainly not "set in stone," but is offered merely as a way of thinking about the purpose of the tools and beginning to distinguish between different types of visual tools, how they were created by their authors, and how they are typically used in classrooms. This view of the interplay of habits of mind and visual tools will be discussed more closely as we begin to also evaluate the strengths and weaknesses of each form in the following chapters.

Bringing forth Costa's habits of mind also gives us greater clarity about how and why visual tools are important and effective in classrooms. In this chapter, we have seen that there is conclusive evidence of the effectiveness of the tools for improving teacher instruction and thus student performance across disciplines and grade levels. But we must ask ourselves: Is there something more for us to learn as educators about visual tools beyond the constrained focus on testable outcomes and student achievement, as documented in these concrete results and as evaluated in schools? I believe there is something more, and I believe it is in the heart and mind of every educator and parent of the children in our schools. The goal of education must be to have our students exit our schools with capacities not presently explicitly taught or tested: to think creatively, analytically, and conceptually beyond the assignments, writing prompts, and tests of the factual information found in content-area texts. It is the facilitation of these kinds of habits of mind.

We now turn to the more practical applications of different types of visual tools with this question in mind: How do we support students to creatively, analytically, and reflectively transform information in every content area into active knowledge using visual tools?

Figure 2.1 Tree Map for Habits of Mind