4. Thinking Maps®: A Visual Language for Learning

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Abstract. There have been a range of different types of visual tools used in schools over the past 50 years such as "graphic organizers," mind mapping, and concept mapping. These tools are grounded in the mapping metaphor, reflecting our capacities to network information and create cognitive maps of content knowledge and concepts. This writing investigates a language of eight cognitive maps called Thinking Maps® and Thinking Maps® Software, used from early grades through college courses to foster cognitive development and content learning across disciplines by all students across entire schools.

4.1 The Mapping Metaphor

Mapping is the overarching metaphor for teaching, learning, and the representation of knowledge in the twenty-first century. This rich conceptual metaphor has a role in helping us understand how visual tools and technologies support learners in their capacity to transform information into knowledge in the "flat world" of communication technologies working 24/7. The common vocabulary of our time – *networking, connectivity, world wide web, interdependence, systems, integrated,* and *internet* – are expressions of the mapping metaphor. Mapping is both a metaphor for connecting and overlapping knowledge structures and also the name for practical visual tools for mental fluency. Mapping is a rich synthesis of thinking processes, mental strategies, techniques and technologies, and knowledge that enables humans to investigate unknowns, show patterns of information, and then use the map to express, build, and assess new knowledge.

The mapping metaphor is understandable and intriguing in a technological sense, yet ultimately this is about power sharing in the creation of knowledge. The gulf between our students' relatively high technological expertise and underdeveloped mental fluency is one of the key barriers we must move beyond in order to enact positive change through knowledge sharing in schools, the workplace, and in global communication. So the mapping metaphor also opens up a central dilemma: our students may be networked to information webs, yet few have developed congruent thinking tools that enable them to consciously pattern information into meaningful, integrated, networked knowledge. At this time in classrooms and workplaces, in lesson plans and meetings, memos and voice/text messages, our communication is often dominated by the one dimensional thread of linear language, a narrow representation that keeps our ideas hidden away in rich but unknown mental spaces, a *terra incognita.*

4.2 Cartography and Cognition

Historically, the unique representations derived from map making are best expressed through the history of cartographic links to cognition and communication, which reveals that this invention was a turning point for human understanding:

> The act of mapping was as profound as the invention of a number system. The combination of the reduction of reality and the construction of an analogical space is an attainment in abstract thinking of a very high order indeed, for it enables one to discover structures that would remain unknown if not mapped (Robinson, 1982, p. 1).

This quotation is drawn from James H. Wandersee's (1990) insightful analysis of the connection between cartography and cognition. He argued persuasively that cartography links perception, interpretation, cognitive transformations, and creativity serving four basic purposes: to challenge one's assumptions, to recognize new patterns, to make new connections, and to visualize the unknown.

Cartography has always been a central form of storing vital information about our surroundings and distant shores, from the ancient mappings of the earth and sky. Humankind has always sought ways to discover and map new frontiers and find our way home by land and sea and, most recently, by air. Cartography has been both a science and a gateway to new learning, but until the last few decades the term "mapping" has stayed within the intellectual domains of astronomers and geographers. Actually, from Africa to the Mayan astronomers, maps have been the documents of discoverers and ownership, and then, often, of domination. If a "discoverer" could map a region, then ownership was established. Planting a flag was a symbolic gesture, but mapping the region was the act of establishing physical boundaries and territories.

The attempt to discover longitude in the eighteenth century was foremost in the minds of seafarers, traders, and governments, as latitude and longitude lines crossed and established the relationships between time and space that could guide adventurers and conquerors alike to unknown lands. The Lewis and Clarke expedition across the western region of North America, like any other journeys into new landscapes, was an attempt to map territories unknown to a new republic so that commerce and land holdings could expand. The "map" that Lewis brought back to President Thomas Jefferson was technical in the geographic sense, commercial in the description of resources, and ethnographic in depicting cultures new to the adventurers:

> Lewis studied maps in Jefferson's collection. He also conferred with Albert Gallatin, a serious map collector; the problem was that west of the Mandans nearly to the coast was terra *incognita.* And the best scientists in the world could not begin to fill in that map until someone had walked across the land (Ambrose, 1996, p. 80).

Now we send captainless ships to distant planets to map and in some cases "own" new territories off the curvature of the earth. The "four corners" of our globe are known, and our technical expertise is often hopscotching over our immediate needs. We have access to electronically mapped terrain through GPS, or global positioning systems. We may be in our car with a map on a screen, guiding us around the corner or into another state. Likewise, and using similar technology for networking information, some of our children, are now interactively using computer screen portals from wireless connections, accessing linked data from points around the world, thus from different points of view. Those views may range from electronic explorers of knowledge on "the net" to mass marketers of goods to exploiters of graphic violence and other morally repugnant materials. They have few filters for all of this information packaged as knowledge.

Our technologies offer exponentially increasing quantities of downloadable information, but few ways of filtering information into practical knowledge. There are few unknown territories in the physical world: the new territories are of human imagination, interaction, communication. We are mapping the human genome system as well as all the systems of the body and mind. The brain is based on pattern seeking and mapping and thus we use cartographic means to discover how we think: we use fMRI's to map that organ of our body that is continuously and unconsciously remapping reality for us every moment.

Educators are now seeing in practice and in the research that visual tools such as MindMapping® (Buzan, 1979), Concept Mapping™ (Novak & Gowin, 1984) and Thinking Maps® (Hyerle, 2004) are supporting students to transform information into useful knowledge. These tools are also facilitating diverse learners from across a range of multiple intelligences (Gardner, 1983) and dispositions of thinking, or Habits of Mind (Costa, 2001) Students are transforming information into knowledge using these applied "mapping" languages in seeming congruence with the unconscious, associative networking of the brain. Pat Wolfe, a leader in the translation of evolving brain research for practitioners offers this connection: "Neuroscientists tell us that the brain organizes information in networks and maps." (Wolfe, Forward in Hyerle, 2004).

4.3 The Cognitive Dissonance of Linear Representations

High-quality visual tools are used for surfacing dynamic schemas, graphic representations that externalize in dynamic blueprint form the conceptual information structures, within the architecture of the brain. This is why visual tools are a breakthrough in education and not just another tool on the sagging toolbelt of endless and uncoordinated "best practices" for teachers. It is now clear that the traditional linear strings of words students see in textbooks and hear from teachers in dominantly "auditory" classrooms do not even come close to approximating the complex visual-verbal-spatial patterning of what is going on in their heads.

Our minds consciously create patterns, our emotions are driven by layers of interconnected patterns of experience, our media thrives on the communication of patterns, and nature – that which we are a part of and surrounds us – is a complex weave of patterns. Some of these patterns are linear and procedural, but the foundation of knowledge from the basic factual knowledge record to decision making borne of evaluative processes are nonlinear patterns. Are thoughts linear? Emotions? An ecosystem? Our values?

Put in the most stark terms, our educational *system* and educational leaders can no longer lag behind the children who sit before handheld computers and access, download and create a complex interweaving of information as we stand before them and speak and write and numerate in linear strings of words and numbers. There is *cognitive* dissonance between the highly constrained linear presentation of information in classrooms as text blocks and the multidimensional, mapping of mental models that the brain-mind naturally *performs* when processing and crafting information into knowledge. I believe that this dissonance is *the* fundamental barrier to improving students' thinking and teachers' capacities to convey and facilitate basic and complex content and conceptual learning for all students.

The double meaning in the term "cognitive" dissonance is clear: *cognitively* we process beyond the linear mindset but we asked students to show their thinking primarily in linear terms. This is disorienting at a most fundamental level. Visual tools *do not* offer a replacement of traditional forms of literacy but an additional way of "showing what you know" that is shifting our perception of knowledge on the most basic level. Why? Because visual tools of every kind, from brainstorming webs and graphic organizers to thinking process mapping are all based on the metaphor of the visual-spatial-verbal *mapping of knowledge*. Like any breakthrough technology, this transformational technology of the mind – the hand drawn and technology based mapping of mental models – includes that which came before. The visual mapping of information into knowledge is what the brain does already and emerges in an historical sense of mapping physical space.

From the point of view of how knowledge is represented, there is a fundamental disconnect between how students and educators SEE and understand knowledge. The primary reason for this is that most educators, as most educational researchers, are primarily text drive and auditory: we live not only by the idea of text books and the spoken word, but also that information is valid only when substantiated in linear text *blocks and strings of sentences*. To find out something we have traditionally read text out of books. To find out what students know we have them write text blocks to us or speak to us in strings of words. This has been our guiding definition of literacy for longer than we can remember. One of the main reasons that learners young and old often have writer's "block" or their thinking is "blocked" is that a guiding metaphor for information could be called the "wall of text." The linear wall of text does not explicitly show the rich networks and patterns of thinking that the author is attempting to present through the only form available: linear representations. When visual tools are presented along side text or used by learners to find the patterns embedded in the wall of text, then what is unveiled is the rich foundational structures of knowledge.

Recently I was working with teacher and administrator leaders from a school system in New York State and, after presenting an overview of visual tools within the context of some of the conclusive research and practice, the literacy coordinator for the district broke through the paradigm for defining "literacy" in classrooms and dramatically offered this epiphany: "For all of these years, I thought it was all about my students speaking and writing, but now I understand that what I really wanted to know was how my students were thinking." The breakthroughs in how we represent information, ideas, and concepts have been occurring over the past 20–30 years from the first uses of brainstorming webs for prewriting processes to concept mapping and systems to diagramming, to an additional, synthesis language of visual tools called Thinking Maps®.

4.4 A Summary Definition of Visual Tools

Visual tools are used by learners, teachers, and leaders for graphically linking mental and emotional associations to create and communicate rich patterns of thinking. These visual-spatial-verbal displays of understanding support learners in *transforming static information into active knowledge*, thus offering additional representational systems for integrating texts of different kinds into visual displays. These visual forms also support the processes of information in linear ways (such as traditional flow charts) and in nonlinear forms such as systems feedback loops and hierarchical category structures. These additional forms for generating, organizing, and reflecting on information offer metacognitive tools for self-assessment in each content area and for interdisciplinary learning that may unite linguistic, numerical, and scientific languages together on the same page.

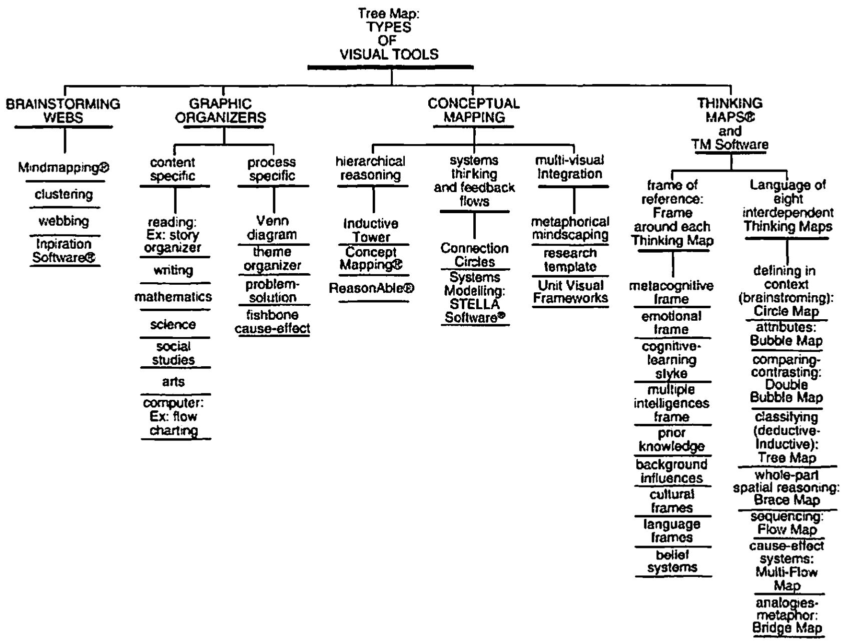


Fig. 4.1. Tree map of types of visual tools.

As shown in Fig. 4.1, I have identified three informal, sometimes overlapping categories of visual tools, each with specific purposes and congruent visual configurations:

Brainstorming webs for fostering creativity and open mindedness;
Graphic organizers for fostering analytical content and process-specific learning;
Conceptual mapping for fostering cognitive development and critical thinking.

A fourth category is a unique synthesis *language* of visual tools that has been used extensively across schools called Thinking Maps® since 1990 (Hyerle, 1993, 1996; Hyerle & Yeager, 2007). This common visual language of visual tools integrates the creative dynamism of webs, the analytical structures of content-specific learning, and the continuous cognitive development and reflections fostered through conceptual mapping. Over time, new visual languages may develop that integrate different visual tools and thus enabling a greater range of thinking, communication and reflection.

Visual tools are used for personal, collaborative, and social communication, negotiation of meaning, and networking of ideas. These graphics are constructed by individual or collaborative learners across media networks and mediums such as paper, white boards, and computer screens. Because of the visual accessibility and natural processes of "drawing out" ideas, many of these graphics are used from early childhood through adulthood, and across every dimension of learning, teaching, assessing, and leadership processes. Visual tools are also used across cultures and languages and may become keys to new levels of more democratic participation and communication in human systems. Across traditional cultures and new "virtual" cultures, visual languages ultimately may be used for uniting diverse and distant learning communities as people in schools, communities, businesses and in different countries *seek to understand* each other through *seeing* each others' thinking and perceptions through multiple frames of reference.

In reviews of practical applications of visual tools (Hyerle, 1996, 2000) it is clear that there are significant differences between student developed maps and what are common known as "graphic organizers." There are many published resource materials that include preformed, highly structured graphics for students to fill in, much like checklists and simple worksheets. Some of these resources are helpful as they guide students through particular processes in an orderly way. The downside becomes evident over time as students may never gain the capacity to map out their own thinking independently from these sturdy, but limiting scaffolds. In contrast, visual tools, that are generated from a blank paper or electronic page *by students* enable them to become the center of learning in order to create conceptually rich models of *their* meaning. While the processes of training students to become independent visual tools users takes time, once students gain basic mastery over the tools from they are able to transform concrete information and concepts bound by linear texts into maps that show patterns that add depth to their understanding of content knowledge. Visual tools offer a third way through the great false dichotomy which we as educators have endlessly debated since the time of John Dewey: *Should we focus more on content area facts or thinking* *process instruction*? I believe that dynamic visual tools offer a third way that triangulates this dichotomy, as visual tools are used for integrating content information and cognitive processes into *forms of knowledge*. Visual tools offer teachers and learners mental maps for trans*form*ing in*form*ation into knowledge using fundamental thinking patterns as the foundation.

4.5 Thinking Maps®: A Synthesis Language of Visual Tools

As shown in Fig. 4.1, a full range of visual tools has been developed and successfully used as pattern-tools for thinking creatively, organizationally, and conceptually. Some tools may focus more on one aspect of thinking and learning, or one form of representation, such as holistic, conceptual hierarchies or intricate feedback loops for representing dynamic systems over time. We can see through the use of these tools and extensive research how students are making sense of their own stored knowledge in displayed "visual schemata" and how they accommodate and assimilate new information and concepts through these richly developed visual tools: brainstorming webs foster creativity, graphic organizers explicitly model more analytical content processes, and conceptual mapping tools for explicitly focusing on conceptual understanding. The book detailing the theory, practice, and research on concept mapping, "Learning How to Learn" (Novak & Gowin, 1984) was an influential text as I began to see how a coherent language grounded in visual tools could be used to mediate learning and as new tools for assessment.

So it was reasonable – and practical as a classroom teacher – to consider and question how this wide range of tools could be synthesized, coordinated, and offered to students in a practical and meaningful way so that they could ultimately take control of their own patterns of thinking. Here are a few of the questions I asked myself as I was investigating and teaching with a range of visual tools in the mid-1980's when I was teaching middle school:

How could student centered visual tools be coordinated in way that they are generative like webs, analytic like organizers, and focused on conceptual learning? Could all learning be held in hierarchies or systems diagrams?

What would theoretically ground an organization of visual tools? How would we organize and link these visual tools?

How would this work in practical ways for students, teachers, and school leaders?

These questions were surfaced for me when I had an opportunity to use a program based on the explicit definition of fundamental cognitive skills – some displayed graphically – as the point of synthesis. The nexus of patterns of cognition and nonlinguistic representations became the theoretical and practical foundation of Thinking Maps as a language of eight nonlinguistic representations defined by fundamental cognitive skills.

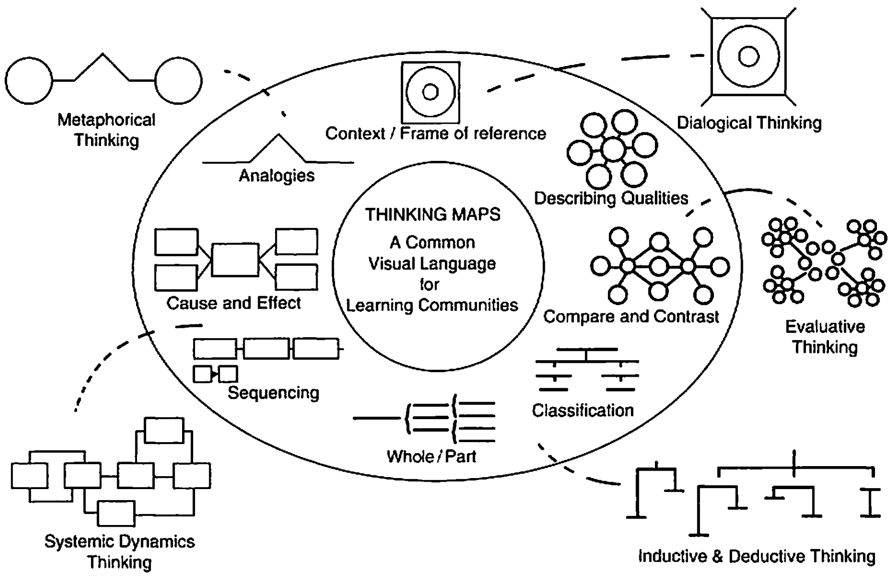


Fig. 4.2. Thinking Maps® as a common visual language.

Thinking Maps is a language for learning that has now been implemented through professional development training and systematic follow-up coaching in nearly 5,000 schools across the United States and internationally since 1990. Teachers, students, and administrators across entire elementary, middle, and high schools are introduced to this language in the first year of implementation through a professional development process that includes workshop training, follow-up coaching, and the development of deep applications in reading, writing, mathematics and technology. The primary outcome of the interactive professional development is that teachers work together over multiple years to *explicitly* teach all of their students across whole schools how to become fluent independent and collaborative users of this language for in depth content learning and transfer of the same language of thinking across all content areas and grades levels. This enables the continuous cognitive development for *all* students as a foundation for lifelong learning.

The effectiveness of Thinking Maps has been established through scientifically based research on nonlinguistic representations and graphic organizers, and extensively documented through test scores and qualitative evidence in academic publications since 1990. Most recently, over a dozen authors from the United States, New Zealand, and Singapore – from high to low achieving schools and from inner city to rural schools – presented the documented results and research on Thinking Maps implementation in the book "Student Successes with Thinking Maps: School based Research, Results and Models for Achievement Using Visual Tools" (Hyerle, 2004). At this time, the most common focus of use of the model, and the documented successes, come in the areas of reading comprehension and writing process. Ongoing research and development on Thinking Maps and other approaches to creating "Thinking Schools" is supported by the nonprofit organization, *Thinking Foundation* (www.thinkingfoundation.org) in order to document how these tools work across grade levels and content areas for a range of students with unique needs.

4.6 Thinking Maps as a Language

The language of Thinking Maps is first and foremost based on eight fundamental cognitive skills. These eight cognitive skills, as shown in the center two circles of Fig. 4.2 are based on a synthesis of cognitive science research, models of thinking developed for psychological testing and educational programs, and a transformation of Dr. Albert Upton's early work in book "Design for Thinking" (Upton, 1960). This model is neither linear nor hierarchical. The eight cognitive skills are: defining in context, describing attributes, comparing and contrasting, classification, part-whole spatial reasoning, sequencing, cause and effect reasoning, and reasoning by analogy. This "language" for thinking is not a comprehensive view of thinking: it identifies coherence and interdependency of eight *fundamental* cognitive skills that ground thinking and learning. Upton drew from his close study of the connection between thought and language and attempted to explain how underlying thinking patterns are intertwined with language. The first modern translation of the Upton Model as the foundation for Thinking Maps came when I systematically analyzed different thinking skills models, tests of cognitive skills, and the field of cognitive psychology. If you look within the outside rectangular frame, the extensions of the maps to more complex iterations are found. The essence of this model is that each tool (and the tools together) may be used at the most complex levels of the human mind.

This model is somewhat analogous to the primitives of any language, such as the eight parts of speech of the English language. The eight parts of speech, consisting of nouns, verbs, adjectives, etc. are used in an integrative, limitless way to produce phrases, sentences, and paragraphs. Of course, there is no hierarchy or procedural linearity in the use of the eight parts of speech. It is a language of eight graphic primitives, much like using the "legend" inset in most maps for reading the different graphic displays. While it is dangerous to proclaim universals – as possibly disrespectful to different cultures, language, and cognitive styles represented around the world – the eight cognitive primitives that ground Thinking Maps have found resonance and relevance as we have introduced the tools in places like Singapore, Japan, Mexico, and of course, in cities in the United States where large urban districts such as New York City work with at least 150 different student languages and dialects.

The claim offered here is that around the world, like universal human emotional patterns such as love, joy, and sadness, there are also basic universal cognitive processes: every child born into this world, for example, comes to learn how to *sequence* the day, *categorize* ideas and objects around them, break down objects *whole to parts* and parts to whole, survive by *causal* reasoning, and reason by *analogy*. For example, there is no doubt that every human being has a visceral if not always conscious understanding of the causes and effects of actions: we would not survive physically, socially, or emotionally in the world if we did not reflexively and reflectively use cause and effect reasoning. The challenging question for long term research is this: how are these cognitive processes mentally "mapped" within vastly different cultures?

Key to the understanding of the eight cognitive processes is the essential interdependence between and among each process, or pattern. The awareness by teachers and students of the *interdependency* of thinking skills is, I believe, a missing link in classrooms today. Educators at every level, and psychologists and researchers, simplify these processes by teaching and testing thinking skills in isolation from each other, implying the use of thinking skills rather than explicitly teaching the interdependency of the processes to students. Thus "thinking" is reduced to isolated skill development rather than as a complex of cognitive processes that must work together to enable students to think at the highest levels of creative and analytical thinking.

A central dimension of the Thinking Maps model is drawn from the field of frame semantics which describes how individuals and groups create personal, interpersonal, and social structures, or patterns, that drive perceptions, language, and behavior. In the context of the map, this means that everyone may understand and utilize the cognitive process of categorization, but the categories carry a different language, content, processes for development, and forms within and across cultures. After playing with and testing the eight maps in isolation and as a language of interdependent tools, I realized what was missing: a way for learners to name and visually represent what was influencing, or *framing* (Lakoff & Johnson, 1980) the thinking patterns they had developed using each Thinking Map. I realized that inherent in the metaphor of "frame" was the visual needed for facilitating reflection. I developed a simple rectangular frame that learners could draw, like a window frame, around any of the maps and thus ask many different reflective questions such as:

- What is influencing how I am seeing this information?
- What prior knowledge is helping or getting in the way of my understanding of this new content knowledge?
- Why did I chose this Thinking Map?
- Is there another or several other Thinking Maps I should use to understand this idea?

In retrospect, and from what we now know about the effectiveness of Thinking Maps from over 15 years of implementations in whole schools, the eight cognitive processes grounding the visual representations are most powerful when the learner adds this metacognitive frame of reference around the map being created. Once a students maps out their own thinking, we want the students to "frame" the map by asking themselves what may be influencing how they are mapping information. The frame offers a concrete visual for them to become self-assessing and metacognitive. When all learners in the classroom or school use the maps and frame, they see each others different ideas in different configurations and this has led to teachers and students having a deeper understanding and empathy for another person's point of view.

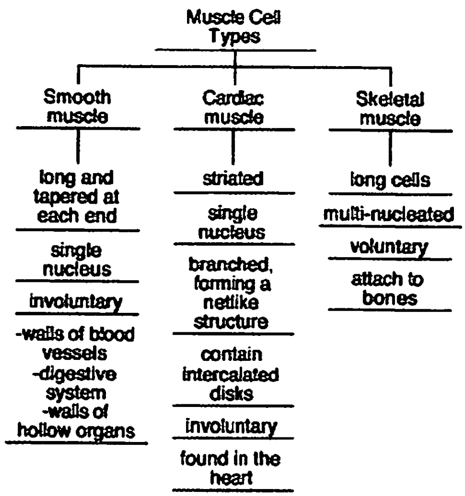
4.7 Five Qualities of Thinking Maps as a Language

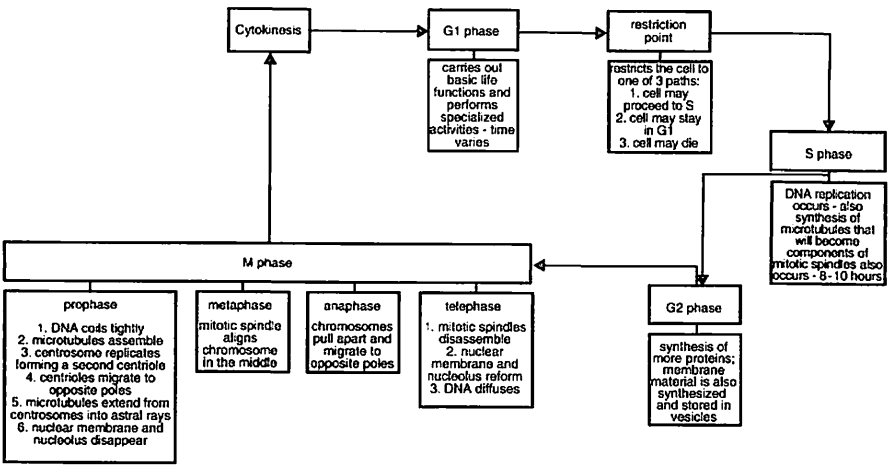
While there are only eight maps – and the "metacognitive" frame that surfaces the culture, belief systems, and perspective of the maker of the maps – there is an infinite number of configurations of each map, much like the English language, which has only eight parts of speech but a vast number of combinations that create infinitely simple to complex variations. Five essential qualities of Thinking Maps are key to seeing how these tools are infinitely expandable and used simultaneously, as a carpenter would use multiple tools for constructing buildings. For example, using the Flow Map as an example, the map is

- Graphically consistent as the Flow is created with boxes and arrows only and can show substages;
- Flexible so as the graphic primitive expands, the flow can be linear and cyclical, or have multiple parallel flows connected;
- Developmental as it can be used at any age level and responsive to simple to complex applications;
- Integrative as it is used across disciplines and for interdisciplinary problem solving;
- Reflective as it is used by the learner to assess how they are thinking and share and compare the visual representations with one another and teachers.

These qualities of each tool and the tools used as a language lead to more complex orders of thinking, such as evaluating, thinking systemically, and thinking metaphorically. When students are given common graphic starting points, *every* learner is able to detect, construct, and communicate different types of patterns of thinking about content concepts.

Let's look at some examples of student work in order to highlight these key qualities of Thinking Maps. Some years ago I received a forty page document from a high school biology teacher outside of Chicago, IL, USA who, along with her colleagues, had systematically trained all of the students in the school to use Thinking Maps and software at a highly adaptable level. This document was a student's work that had been generated using Thinking Maps Software (Thinking Maps, Inc., 1997, 2007) developed over a year's course from a biology text. With most chapters she decided which maps best reflected the key information in the text, and with accuracy and great clarity displayed, for example, types of cells using a tree map and the properties of each, the cycle of cell, and dozens of intricate interrelated parts of a muscle using a brace map.


Muscle Cell Types
Smooth muscle
long and tapered at each end
single nucleus
involuntary
-walls of blood vessels -digestive system -walls of hollow organs
Cardiac muscle
striated
single nucleus
branched, forming a netlike structure
contain intercalated disks
involuntary
found in the heart
Skeletal muscle
long cells
multi-nucleated
voluntary
attach to bones


Cytokinesis
G1 phase
carries out basic life functions and performs specialized activities - time varies
restriction point
restricts the cell to one of 3 paths: 1. cell may proceed to S 2. cell may stay in G1 3. cell may die
S phase
DNA replication occurs - also synthesis of microtubules that will become components of mitotic spindles also occurs - 8-10 hours
G2 phase
synthesis of more proteins; membrane material is also synthesized and stored in vesicles
M phase
prophase
1. DNA coils tightly 2. microtubules assemble 3. centrosome replicates forming a second centriole 4. centrioles migrate to opposite poles 5. microtubules extend from centrosomes into astral rays 6. nuclear membrane and nucleolus disappear
metaphase
mitotic spindle aligns chromosome in the middle
anaphase
chromosomes pull apart and migrate to opposite poles
telephase
1. mitotic spindles disassemble 2. nuclear membrane and nucleolus reform 3. DNA diffuses

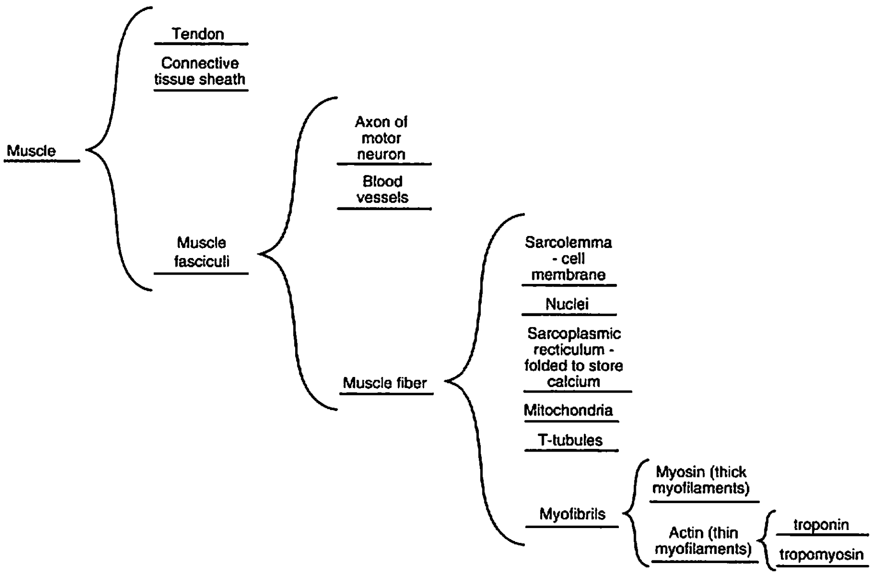


Fig. 4.3. Types of cells, cycle of cell, muscle parts.

She was also able to show in several maps that she could map out the feedback loops of different body systems, comparison of different processes, and properties of unique parts of the body. At the end of the year, with her notes contained in maps which reflected the conceptual content of the chapters, she was able to spread her documents out for review for exams. But her teacher was also able to assess how this student drew the information in the chapters together conceptually.

This student example also reveals aspects of the five qualities of the Thinking Maps language. The graphic consistency and flexibility of each tool enable this student to start with three different graphic primitives, expand each map, while holding onto the basic forms. Because of the common graphic unique to each thinking process, the student's teacher and peers could easily read and assess the map for factual content information, conceptual clarity, and interpretation. This student was also showing the advanced developmental progression from learning the basic elements of each map to complex applications, in this case using Thinking Maps Software. We see this developmental aspect of the maps as first grade students, college students, and school administrators alike are able to use each map in novel applications as they grow from novice to expert users of the tools. Given a full view of the forty pages of Thinking Maps developed by this student over the course of the year, we also witness both the integrative and reflective dimensions of the language. She was able to integrate multiple maps together (for example, information on types of cells and the cycle of a cell) and evolve a deeper understanding of how this information works together. This student also, along with her teacher, could use the maps as what Arthur Costa has called, "displayed metacognition." Teachers and students alike may use the maps for "bifocal" reflection by assessing the development of content/conceptual knowledge while also focusing on the cognitive development of the individual student. Most often in classrooms students' content knowledge is assessed through various means of assessment – including linear written responses and multiple choice items – but rarely are teachers and learners looking closely and over time at the development of thinking processes.

What is also interesting in the forty page document is that beyond the rich mapping of content knowledge, this student was able to work across different types of maps representing different knowledge structures. More specifically, she could map information hierarchically when needed, much like the dynamic form of Concept Mapping® developed by Novak and Gowin or the top-down design of software such as ReasonAble®. She was also able to surface and model feedbacks in systems much like the rich mapping of systems dynamics generated from using STELLA® software and other systems approaches. This reveals a unique characteristic of Thinking Maps as a language. Each visual tool comes with its own theoretical framework for *defining* how knowledge is constructed: concept mapping is based on holistic hierarchical logic and systems diagramming on interdependent feedback flows. This opens conversations in classrooms about how we *see* knowledge that does not surface often in the linear form of texts. Each visual tool thus offers students and teachers a theory of knowledge that is surfaced visually.

Thinking Maps, as a synthesis of different types of visual structures works together as a language based on eight different ways of seeing information, how knowledge is structured, and how these different forms may work together. The difficulties faced with the implementation of Thinking Maps in schools for faculty and students is the same as with many innovations. One of the most problematic issues is the concern teachers, administrators, and educational leaders have for staying focused on discipline specific learning and "content skills" such as, for example, reading comprehension, math, and science skills. Though there is a great degree of overlap, the idea of a generalized thinking and problem-solving model for students to use independently across disciplines is still antithetical to the existing structure of schools and common assessment factors. In this time of high-stakes testing in the United States, the pressure to focus on content specific skills overrides cognitive skills development and the facilitation of problem solving across disciplines. But the theoretical assumption that there is a common visual language for transferring "thinking skills" across disciplines also may be challenged by researchers and practitioners as a search for "fools gold." Thus, much of the professional development work that is conducted in order to sustain Thinking Maps across an entire faculty over multiple years is often driven by the need, as articulated by teachers and administrators, to continually find ways to refine the use of the maps to meet the specific assessments for passing a test or course. Where schools have sustained the use of Thinking Maps over multiple years to the point of students and teachers gaining fluency with the tools, the results show positive changes in student performance and teacher effectiveness. Where the tools are implemented with minimal follow-up support and without purposeful use as student centered tools, the work becomes merely an isolated set of graphics for isolated uses.

4.8 Whole System Change

The discussion of the range of different types of visual tools and the language of Thinking Maps presented in this chapter provides a new metaphor, and theory-embedded tools, for communication for students, teachers, administrators and the whole community of learners in a school. Through this we see that students develop essential Habits of Mind (Costa & Kallick, 2007): to be creative and flexible, to persevere and to be systematic, and to be reflective and self-aware of cognitive patterns to the degree that they can independently *and* interdependently apply these patterns to challenging performance. At any time learners can access this thinking language – using it on paper or through software – to construct and communicate networks of mental models of linear and nonlinear concepts. As students across whole schools become fluent with Thinking Maps, this array of eight visual tools becomes a common visual language in the classroom for communication, cooperative learning, and for facilitating a deep empathy for how others think as well as for the *continuous cognitive development* of every child over a lifespan of learning.

Yet, we also now know that our students must continue to grow and adapt over their lifespan. When we look forward into the decades of the twenty-first century with technology growing exponentially, we realize that explicitly supporting students in their capacities to think and problem solve independently and collaboratively across content areas, languages, and cultures may be one of the linchpins in an evolution in how we as human beings transform information into meaningful knowledge.

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