The Universal Cognitive Grammar of Systems Mapping: A Rubric to Evaluate the Various Tools and Techniques of Systems Mapping

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Abstract: It is well established that visualization is of paramount importance to individual and collective cognition, understanding, imagination, innovation, and knowledge creation. This paper explores the research, theory, and practice that helps us to define and explicate the processes of *Systems Mapping*. It provides three critical insights: (1) that "visualizing" is a *proxy* for numerous other functional operations such as: tactile or tangible manipulation and movement; object-orientation; social navigation; and, embodied learning; (2) that any definition of Systems Mapping that does not include an explication of the implicit cognitive structures is lacking; and, (3) that Systems Mapping, like Systems Thinking, must be derived from a universal cognitive grammar (UCG) that parallels physical structures in the universe. The paper concludes that a Rubric to Evaluate Systems Mapping Tools is needed to assess the necessary and sufficient features of any Systems mapping medium (i.e., internal thought, white or blackboarding, tactile manipulatives, software, group process, etc).

Systems Mapping | Visual Mapping | universal cognitive grammar | DSRP | Policy analysis methods

Contents

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1. From Cave Art to Software: A Brief History of Some Examples of Systems Mapping

Humans have been using visually mapping and physically representing ideas for at least 40,000 years. Paleolithic art*, whose main topics were food, fertility, and animals, was an attempt by Stone Age peoples to understand and gain some control over their environment (1). Cave painting did not only serve a ceremonial purpose (1), but it was also a means to understand a volatile, uncertain, complex, and ambiguous world (VUCA world). The Altamira cave paintings dated to between 35,000 and 11,000 years ago (2), Egyptian hieroglyphics date back to around 5,000 years (3), and Maya architecture of 1,200 years ago (4) shared a similar purpose: *to communicate knowledge*.

Take, for instance, the Temple of Kukulkan in Chichén-Itzá, Mexico depicted in Figure 1, which was voted as one the Seven New Wonders of the World (5). The Temple of Kukulkan (4) provides a metaphor for systems mapping because it illustrates the inseparability of five principles that must be recognized as foundational to effective systems mapping if it is to become a mature and useful field:

1. Systems mapping is visual;
2. Systems mapping is tactile;
3. Systems mapping is object-oriented;
4. Systems mapping is social; and
5. Systems mapping is embodied.

A. Early Mapping The Temple of Kukulkan, depicted in Figure 1, is not only visual and tactile, it is also an embodied representation of the Mayan calendar, but it is also a religious shrine and social center. Each of its four sides has 91 steps, which summed together with the top platform makes 365 steps—one for each day of the year—making the Temple a one-to-one object-oriented exemplar. Also, viewing the pyramid on one side, shows that the corners of its overlapping platforms add up to 18, which are the 20-day months of the Mayan calendar. And, incredibly, twice a year on the spring and autumn equinoxes, a shadow falls on the pyramid in the shape of a feathered serpent, representing the Mayan god Kukulkan. In other words, the Temple of Kukulkan is a multisensorial, embodied, social, and experiential systems map of Mayan Cosmology.

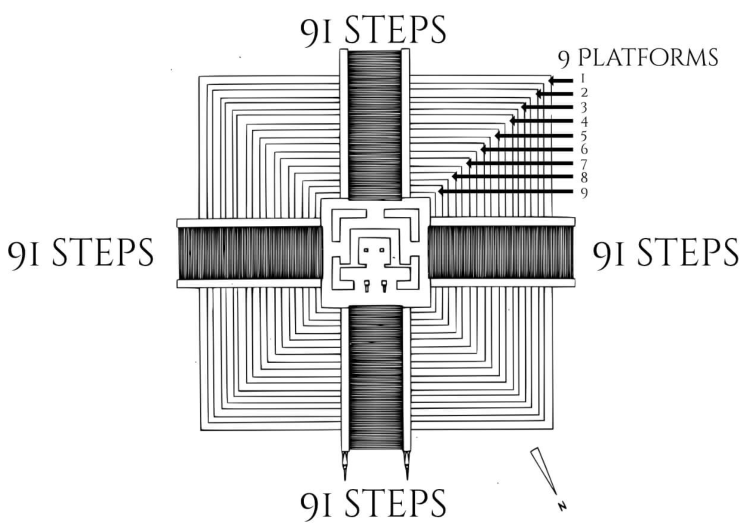


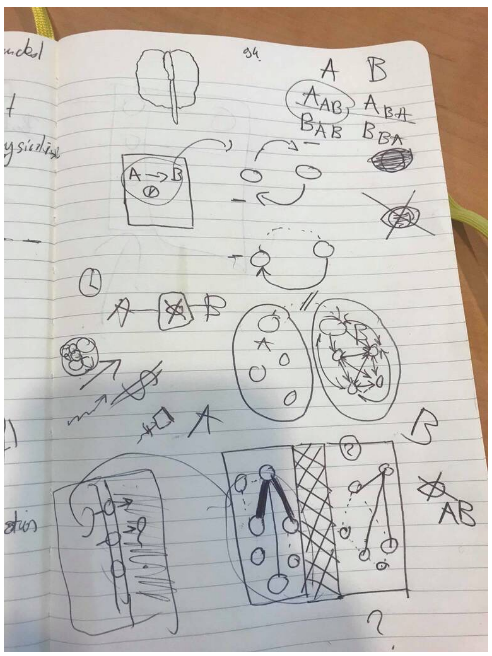
Fig. 1. Calendar representation of the Kukulkan pyramid.

We will deal in greater depth with the term “systems” later in this chapter. Nevertheless, the term “mapping” is often equated with *visual*. Most maps (planimetric road maps, topographic contour maps, etc.) that we are familiar with offer us a visual representation of a particular place. For our purposes, we want to elaborate on two facets of this common awareness of “mapping.” First, that while maps are visual, they are also tactile, object-oriented, embodied, and social. But second, and perhaps more importantly, maps are a “mapping” of one domain to another domain. They are representational. The map, as

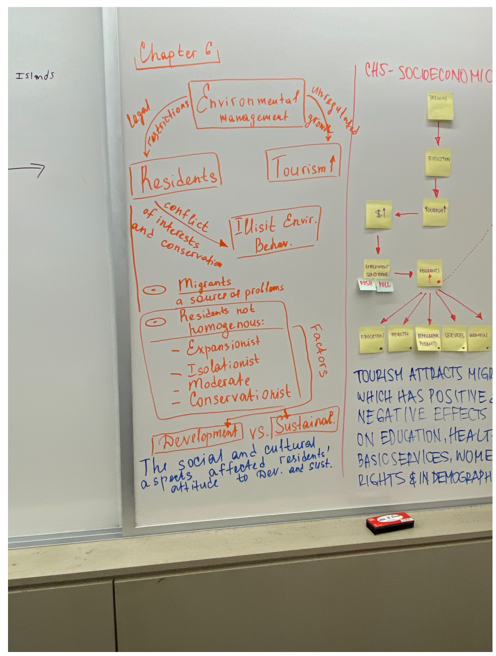
*Paleolithic Art refers to the Late Upper Paleolithic period, which began roughly around 40,000 years ago and lasted through the Pleistocene ice age that ended about 8,000 BCE (1) they say, is not the territory. But the map approximates the territory, and in that sense, it must adequately mimic (analogously map onto) the domain it represents. This second item—that mapping is a mental representation—will be handled in greater depth and illustrate why it requires a *fifth* element: a universal cognitive grammar (UCG). But first, we explore the first four principles of systems mapping and their *inseparable intersectionality*. That is, they do not occur separately, but are intertwined.

Visual mapping has existed since human beings started thinking abstractly, and there are innumerable manifestations of this concept. As we will learn in this chapter, complex and advanced knowledge can be transmitted through a variety of ways; cave art, hieroglyphics, pyramids, or scribblings on the back of a napkin (6). Note that we offer only a handful of examples of systems mapping, but there are many more. For instance, are you taking notes as you read this? Are you highlighting the text? Are you drawing? Are you consciously or unconsciously creating mental imagery as you read? If you answered yes to any of these questions, then you engaged in a form of systems mapping. Whether we do it consciously or not, every day we transmit and learn information through systems mapping by applying quotidian tools such as tables, graphs, flow charts, outlines, tree diagrams, brainstorming, or use a pencil, paper, a whiteboard, a computer application or our own mental image-ination (6). There are countless mediums (both discovered and used and those yet to be discovered) that can facilitate systems mapping. We will explore a few of them and then move on to the underlying principles that make all of these things, manifestations of a single practice: systems mapping.

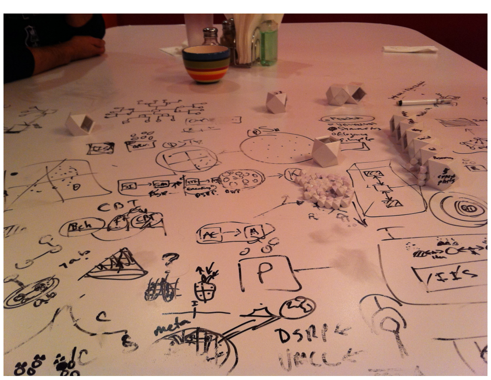
B. Blackboarding If we travel two hundred years back in time, we will find that one of the most influential technological innovations in the field of education is the blackboard. Teachers created the blackboard to visually demonstrate ideas to a group of learners (7). The **blackboard** became, and remains today, a fundamental tool in the classroom for visualizing and connecting ideas, we learn by making connections (7). Of course, the blackboard has led to the modern day **whiteboard** as one of mankind's most popular systems mapping mediums.



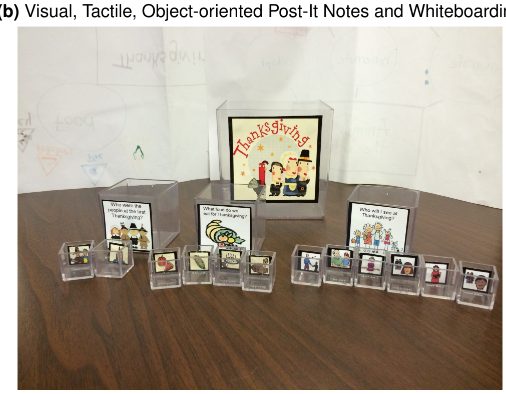
(a) Example of Visual, Object-oriented Systems Mapping in Notes



(b) Visual, Tactile, Object-oriented Post-It Notes and Whiteboarding



(c) Table Whiteboarding combined with Tactile Manipulatives (ThinkBlocks)



(d) Educational Mapping of Thanksgiving with Tactile Manipulatives (ThinkBlocks)

Fig. 2. Systems Mapping on Different Medium

C. Note taking For similar reasons, **note-taking** (as shown in Figure 2a) has been a long-used method by students, academics, and professionals for learning and understanding concepts that can take many forms. For example, as a student in the 1960s, Tony Buzan noticed that his classmates with notes filled with doodles and images were better at learning. Years later, Buzan found that famous thinkers, such as Leonardo da Vinci and Albert Einstein, also used notes connected to drawings as part of their creative process. Buzan trademarked this way of capturing ideas as **Mind Mapping**, which involves the placement of an image in the center of a map with branches drawn to represent connected ideas (8).

D. Tactile Manipulatives Today, among the most famous and widely used tools for visual mapping are **Post-it® notes**. Initially used by 3M employees to communicate around the office, these notes created a whole new way of communicating and brainstorming ideas using colorful and inexpensive pieces of paper as shown in Figure 2b. Post-it® notes are almost ubiquitous[†] because they are tactile and mobile, and easily help us understand how things and ideas relate to one another.

E. Habit Of Mind Many years ago, during a research interview with subjects on a study on tactile manipulatives called "ThinkBlocks," the Cabrera's experienced one of those moments researchers sometimes refer to as a Eureka! moment. **ThinkBlocks** (see Figure 2c and 2d) are a tactile manipulative invented to help graduate and doctoral students at Cornell University learn systems thinking and build physical models of their dissertation topics. ThinkBlocks are designed to model concepts and build thinking skills based on a universal cognitive grammar (UCG) (10) called DSRP (i.e., four processes—Distinctions, Systems, Relationships, and Perspectives that underlie all cognition, and are universal to the process of structuring information). ThinkBlocks allow the user to assign concepts to blocks by writing on them with dry-erase markers (make distinctions), and then associate them with other concepts by using smaller sized blocks (draw relationships), nesting blocks within blocks (to build part-whole systems), and looking at blocks from the perspective of other blocks (perspective taking) due to the translucent properties of the blocks.

In this study, the subject (a pre-teen boy) had been using the tactile manipulatives for one week and he said, "you know those blocks we've been using?" to his mother, "I find that even if I am somewhere where they are not that's okay because all the things I can do with them to make things more clear, I can now do in my head. I just move the blocks around in my head and there are concepts on them." The power of tactile manipulatives is many-fold, but this story illustrates the true purpose. We "externalize" our cognition (what is sometimes called "distributed cognition") when the concepts are hard, or the problem we are solving is complex. We do this to get our thoughts out of our heads and into a physically manipulateable space of ideas. When we practice doing this, we are able to handle increasingly complex ideas in our heads, because we can mimic what we were doing in a physical environment in our heads. The level of complexity we can deal with in our heads is increased because we are able to create something like a virtual whiteboard, post it notes or blocks to concretize ideas. When the complexity of the situation exceeds our internal ability to map, we feel the urge to "get up on the board," "draw it out," "move things around." In other words, the more we do it "out there," the more we can do it "in here."

F. Computer Software In this Digital Age, visual mapping has evolved along with technological advances. Through recent mapping software (such as Plectica 3, Whimsical, Kumu, various Mindmap applications, Miro, Orgpad, Insight Maker, Milanote, Vensim, STELLA, etc.), one can create in minutes visually-appealing maps that facilitate the understanding of complex ideas (11). With a computer and one click, any person can reduce complex relationships into compelling visualizations (12). New mapping software also allows individuals and teams to brainstorm (11), create flowcharts (13), build networks of interconnected ideas (14), and organize projects into visual boards (15). Complex problems that humans would usually spend days or months understanding are now possible to solve in minutes. Further, digital mapping allows us to easily share, replicate, and build upon previous maps.

[†] According to 3M, Post-it® notes are available in more than 150 countries (9)

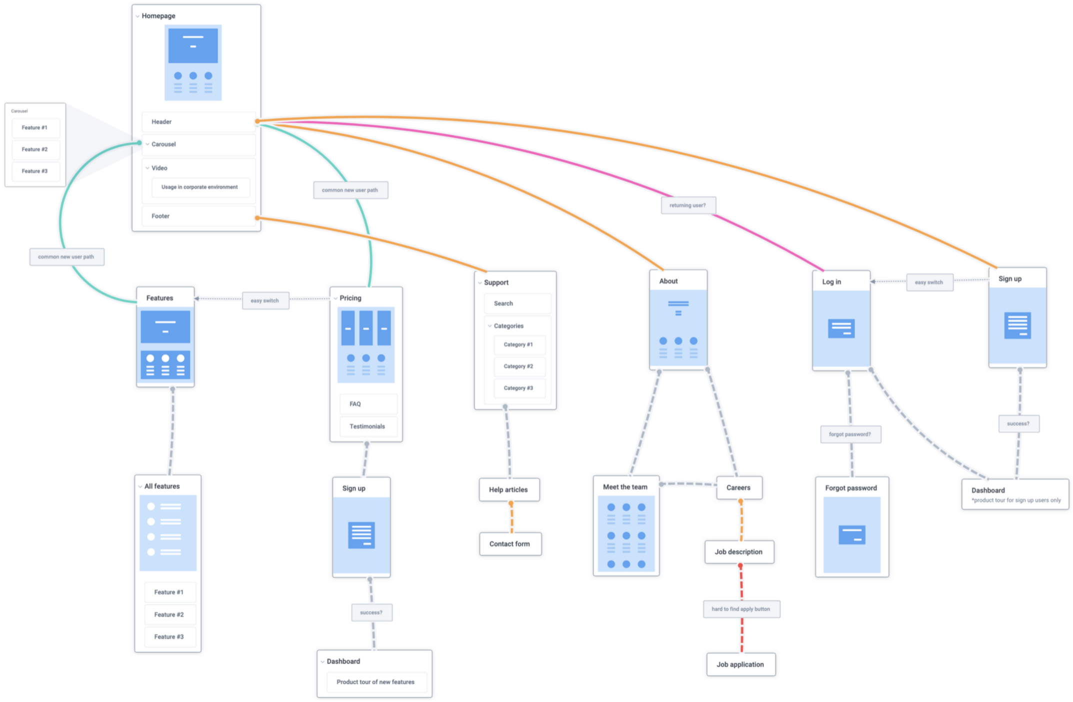


Fig. 3. Systems Mapping on Plectica Software

G. Collaboration Despite the unrest and discord that is prevalent in human society, we are social animals. Our success as a species depends on "being social", which is hardwired into us. It should also be hardwired into our systems mapping practices. There are of course times that systems mapping occurs in private, but it is the rare occasion that whatever is being mapped (even privately) isn't in preparation for some future social sharing. At the same time, most (if not all) of the truly wicked problems we face as organizations or as a society (16) *require* us to work together. Systems mapping (even when it is being done privately) is an inherently social activity in the same way that learning is (17).

Fig. 4. The importance of Social Learning Highlights the Importance of Systems Mapping as a Social Exercise

2. Why Do We Map? The Significance of Systems Mapping

Have you ever wondered why babies touch, taste, and manipulate every object they can? Why do babies look [longer] at things unfamiliar to them, grab at them with their hands and immediately shove them into their mouths (often, much to the chagrin of their parents)? Or why, when knowledge is overwhelming, do we feel the need to spill it out onto the page, the whiteboard, or the table? Or why do you need to cook the dish to learn the recipe? There is a simple explanation for these behaviors: humans learn through all of their senses, but especially through their eyes and hands (and tongue) (18).

Anything that humans can use to physically build their thoughts, ideas, and concepts will assist them in constructing knowledge (19). The connection between understanding and our senses—touch, sight, hearing, smell, and taste—is deeply evolutionary, instinctual, and begins with infancy and continues throughout our life (10). Our brains have more neurons linked to our visual, tactile and taste cortexes than to any other part of our body (18). In short, we are architects of knowledge who build intellectual constructions through our physical experiences (10).

There are three critical aspects of visual mapping that make it a powerful tool. First, visual mapping is *visual*[‡]. Second, visual mapping is kinesthetic (*touching* and *moving*). Third, visual mapping is *object-oriented*. Visual mapping helps us comprehend, contextualize, organize, retain, and communicate ideas. It also helps synthesize multiple viewpoints, integrate knowledge, and collaborate with others. Visual mapping makes it easier to think, learn, and share knowledge. And each day, we are learning more and more about the power of imagistic thinking to comprehend, create, and share ideas (18).

Defining Systems Mapping is a non-trivial exercise with a great deal of complexity. But understanding its current and future potential significance is far less difficult. Seemingly complex questions like, "Why do people map?", and "When do they get the urge to map?", have a surprisingly simple answer.

The answer is that people (as well as organizations, disciplines, projects, governments, communities, etc) feel the urge to "map systems" as soon as those systems start to feel overwhelming, when they can't keep it all in their heads, and their brain needs to spill out onto a page, a whiteboard or a table. Or when they need to work together, and take multiple perspectives to get along. Or when the problem is extra hard, durable, or wicked. Consider the following two applications (scientific and digital) as examples of when systems mapping is used and where there is tremendous potential for future use and insight:

First, science is hard. Even mapping out the most basic natural process yields often unimaginable complexity. Mapping a whole discipline of knowledge or all of knowledge itself is, (of course) non-trivial. In his book, <u>Mapping Scientific Frontiers: The Quest for Knowledge Visualization</u>, Chen (22) explores the many complexities of the scientific field, and the difficulties of mapping it. The system of knowledge dispersion must be taken into account first and foremost. Chen writes, "As the number of new scientific publications arrives at a rate that rapidly outpaces our capacity of reading, analyzing, and synthesizing scientific knowledge, we need to augment ourselves with information that can guide us through the rapidly growing intellectual space effectively." In order to begin the task of mapping scientific knowledge, the field must be broken down into parts. Chen identifies the macro (structure and dynamics of a discipline), meso (system of groups), and micro (individual scientists and approaches) scales as perspectives to be taken into account. Chen explains the complexity of the task as so:

> "Mapping scientific frontiers involves several disciplines, from philosophy of science, sociology of science, to information science, scientometrics, and information visualization. Each individual discipline has its own research agenda and practices, its own theories and methods. On the other hand, mapping scientific frontiers by its very nature is interdisciplinary. One must transcend disciplinary boundaries so that each contributing approach can fit into the context."

One's mapping tools must be capable of such complexity in order to successfully achieve the kind of map Chen dedicated his book to. Likewise, mapping what any individual [student] knows or what a category of individuals [students] should know is difficult. In, <u>Digital Knowledge Maps in Education Technology-Enhanced Support for Teachers and Learners</u>, Ifenthaler and Hanewald (23) provide a deep review of education mapping. In education, how students learn has long been a topic of interest. Ifenthaler wrote, "Instead of merely memorising facts and reiterating the teachers explanations, Ausubel Assimilation theory signalled the power of understanding the material and thus the significance of meaningful learning. He suggested that knowing rather than remembering was the key. It could be achieved by organising the knowledge and then building on these already familiar concepts through direct experiences or observation of objects which then constructed new knowledge." This led to the use of mapping and visualization in education and student learning. Now the debate has shifted as to whether mapping on paper or using software is better. Luckily, Ifenthaler covered this as well. He writes:

> "The most obvious advantages of manual maps are the low cost and low technology involved and their spontaneous production. Hand-drawn maps can be designed on almost anything (i.e. a napkin, paper table cloth, white board) as only a surface and writing implement are necessary. Hence, hand-drawn maps can be produced anywhere, whereas digital maps will always need a device (i.e. laptop, desktop) which is not only costly to purchase but may have to be also powered up before it is ready to use. The disadvantage of hand-drawn maps is the permanent fixed manner with little option to modify the map other than to engage in the messy and time consuming task of erasing or rewriting a manually composed map."

[‡] Of course, globally, at least 2.2 billion people have a vision impairment or blindness, which means they rely on their other senses to understand the world (20). Or does it (21)? Evolutionarily our species is visual and tactile (our brains are "wired" to our eyes, hands, tongue); blindness is a genetic or environmental anomaly which does not "erase" this wiring. That's sort of precisely the point of where we want to go with SM is that it is "multisensorial" . So, while I love this transition and we should keep it, we need to be somewhat cautious about buttressing the "not everyone is a visual learner" trope. I think it's a bit more complex than that.

In his argument for digital mapping, he explains that,

> "The use of mapping software that is freely and easily available on the Internet, with a range of sophisticated features that are quick to master due to their almost intuitive use, enables the creation of large and complex digital maps. They can be instantly and infinitely revised, remixed, reproduced, redistributed and displayed in various formats (e.g. jpg, .png, .svg, doc, docx, ppt, interactive whiteboards, wikis, blogs or web pages). Electronic versions can be produced either synchronous or asynchronous—by one person or a group of people and then revised, stored, printed out, replicated, exported into other files or deleted."

All in all, the act of mapping aids in student learning, whether it's done on paper or on a laptop. We map when we want to see things that are hard to see. We do not map when things are obvious. We map when things are complex, confusing, bewildering or curious. We map to share with others and we map together. We map to make the intangible tangible. We map as a way to enhance our image-ination. Building mental images aids our understanding. But mapping itself is not merely useful, it has enormous potential, especially if done right. Let's take a look at three examples where systems mapping (in this case a form of visual mapping) has had an enormous impact.

A. Little Pictures Transform Physics A picture really is worth a thousand words. Maybe more. A picture can revolutionize a field. But it depends on how insightful the underlying cognitive architecture of that picture is. In 1948, nobel laureate, polymath, bongo player, and one of the founders of the quantum theory of physics, Richard P. Feynman, applied his considerable genius to arguably some of the most difficult mathematical problems in science. His solution was to combine a bunch of simple standardized squiggles into a diagramming technique that has since become known as "Feynman Diagrams"5(24). These diagrams are pictorial representations of mathematical expressions that visualize the behavior of subatomic particles (25). Feynman published the first Feynman diagram in *Physical Review* in 1949. "Feynman diagrams look to be pictures of processes that happen in space and time..." and in essence serve to be approximations of reality (or mental models) (26). Wilczek describes it as "a beautiful new way to think about a fundamental process (26)." In order to draw Feynman Diagrams, you need only a pencil and piece of paper. Even a foggy window and an index finger will do.

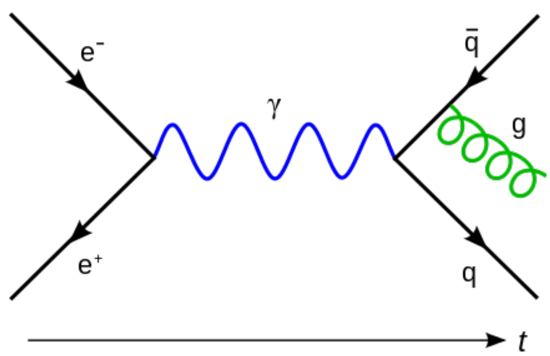


Fig. 5. Feynman diagram, shown: "an electron (e^-) and a positron (e^+) annihilate, producing a photon (γ, represented by the blue sine wave) that becomes a quark–antiquark pair (quark q, antiquark $\bar{q}$), after which the antiquark radiates a gluon (g), represented by the green helix)."

David Kaiser (27) wrote a wonderful book on this topic entitled, Drawing Theories Apart The Dispersion of Feynman Diagrams in Postwar Physics. But, let us summarize the salient story of their rise to the pinnacle of scientific achievement. Mahatma Gandhi said, "First they ignore you, then they ridicule you, then they fight you, then you win." That is the history of Feynman Diagrams. At first they were ignored by the most notable of physicists. Next these little diagrams were ridiculed and even banned from use by professors at universities like Cornell and Harvard because they thought students who used them were "cheating" by not instead solving the difficult equations using classical notation (students loved them—and even used them secretly—because they made heretofore unreachable physics tangible to their mind's eye). Finally, Feynman Diagrams won the day. Today, as just one example, the search for the most elemental particles in the universe at places like CERN and the Large Hadron Collider (LHC) are predominantly guided by Feynman Diagrams. Think about this for a moment: the most brilliant minds, the toughest problems, the most difficult scientific ideas, the most complex mathematics, use little squiggly pencil drawings to help them figure things out. If it wasn't true, it would be hard to fathom.

As Einstein once put it some ideas are, "So simple, only a genius could have thought it." The power of Feynman Diagrams is not only that they are powerful tools for understanding difficult things, but that they are simple tools. Tools that help us to map tiny systems based on the universal properties of those systems. In one sense, Feynman Diagrams provide not only a visual, tangible, object-oriented, and social tool, but also a universal grammar for subatomic processes.

Funny story. Richard Feynman was a bit of a party animal. He liked to play bongos and drove a VW bus. One day at a gas station in the Southwestern United States, a group of doctoral students in physics approached him and asked, "hey man, why do you have a Feynman Diagram painted on the side of your bus?" Feynman replied, "Because I am Feynman!" To paint an enlarged diagram on the side of his bus is a testament to the fondness he must have felt for these little drawings. For he knew that they held the secrets to the universe and to our understanding.

B. Little Pictures Transform Chemistry In Image and Reality: Kekulé, Kopp, and the Scientific Imagination, Rocke (28) speaks of the scientific "image-ination." What he means is that the history of scientific breakthroughs is littered with visual thinkers. But, we do not mean visual thinking merely as a phenomenon of the optic nerve, but of the whole brain and mind. By which we mean to say—as does Rocke and Miller (29, 30) and McGinn (31)—that the inseparable intersection of visual, tactile, and object-oriented (experiential) thinking leads to a kind of "mental imagery" that goes far beyond what the eyes see. It allows us to see and manipulate with our minds that which cannot be seen by the optic nerve alone. Rocke describes it this way:

> "One can learn new things from mental images, even from those that occur in not-fully-conscious mental states...For instance, one would scarcely be inclined to believe that Poincaré's (or anyone else's) work in the theory of differential equations, whether conscious or unconscious, could routinely involve mental imagery. One would suppose that being in the realm of pure mathematics, his theories must have arisen through pure ratiocination. It is therefore surprising to note how filled with images are Poincaré's descriptions of what happened in his mind during his eureka episodes, which, as we have seen, are surprisingly parallel to the stories that Kekulé told. The prominent contemporary American mathematician William Thurston has even averred that "[t]hinking is really the same as seeing." (page 325)

Rocke convincingly shows that the invention of visual chemical diagrams (i.e., little pictures of chemical structures) transformed the field of chemistry itself. He tells the fascinating story of how architect-turned-chemist, August Kekulé, in 1857, invented structural formulas. A structural formula is a visual representation of the molecular structure of a chemical compound. These "little pictures" let us imagine the arrangement of atoms and their chemical binds (relationships) in three dimensional space as shown in Figure 6.

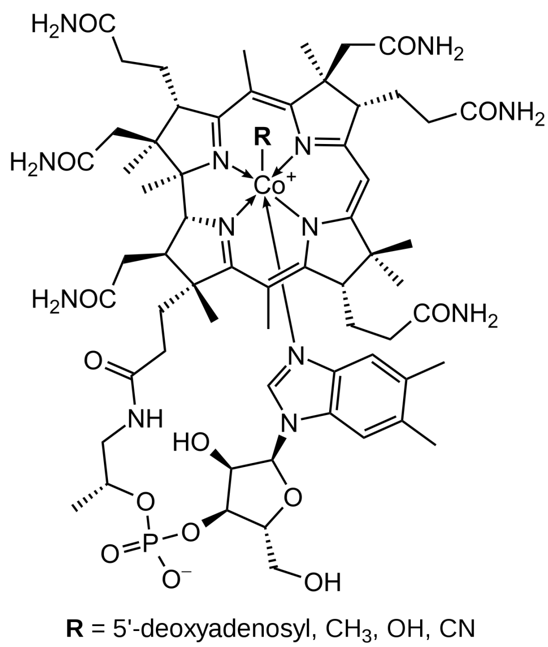


Fig. 6. Structural Formula (ie., little chemical pictures). Shown: "Skeletal structural formula of Vitamin B12. Many organic molecules are too complicated to be specified by a chemical formula (molecular formula) (32)."

Unlike chemical formulas, these pictures show a complete picture because they are not limited by the number of symbols available. In inventing these "little pictures" Kekulé transformed chemistry, as he was referred to as a "hero" of chemistry by J. H. van't Hoff in the obituary he wrote about his mentor:

> ...partly because of his imaginative visual propensity extending down to the molecular world, and this habit of mind could possibly be traced to his early training as an architect... he [Kekulé] always laid stress... on the necessity which he ever afterwards felt of having before him, if possible, an actual picture of any problem he was dealing with. He was doubtless right. After all, he remained an architect to the last: only it was the architecture of molecules, instead of that of buildings, with which it was his lot to concern himself. (Page 65-66)

Rocke writes of the historical research that led to:

> "the conclusion that mental imagery often accompanies creative and productive scholarly work, including scientific work. Mental imagery may even be constitutive of creative science" (Page 327) ...Chemists of this time could not determine exact stereospatial positions of unseen atoms within a molecule...their formulas could do more than simply summarize reactions. For many simpler organic substances chemists often could map out the connectivity of the individual atoms— the "chemical structure" of the molecules that compose them. (Page 171)

Additionally, Rocke articulates the historical significance of Kekule's work:

> "...there can be no better subject from which to extract concrete examples of productive use of the interconnected world of images, models, and "paper tools" than the crucial period in the history of science when chemists first began to be convinced of the reality of their mental representations, and charted a path to show all scientists how best to explore the world beyond the immediate reach of the senses. In this way, the history of chemistry might contribute to a fuller understanding of the creative powers of the human mind." (Pages 340-341)

These examples of the history of chemistry and science from Rocke's extensive historical analysis show the power of little pictures that we see not only with the eye, but also that we see with the mind—mental imagery.

C. Little Pictures Transform Every Discipline Other than the No. 2 Pencil, it is hard to imagine a tool of knowledge that is more pervasive, more useful, more used, and more widely applied than network theory. It is a tool that helps us to build knowledge across nearly every discipline.

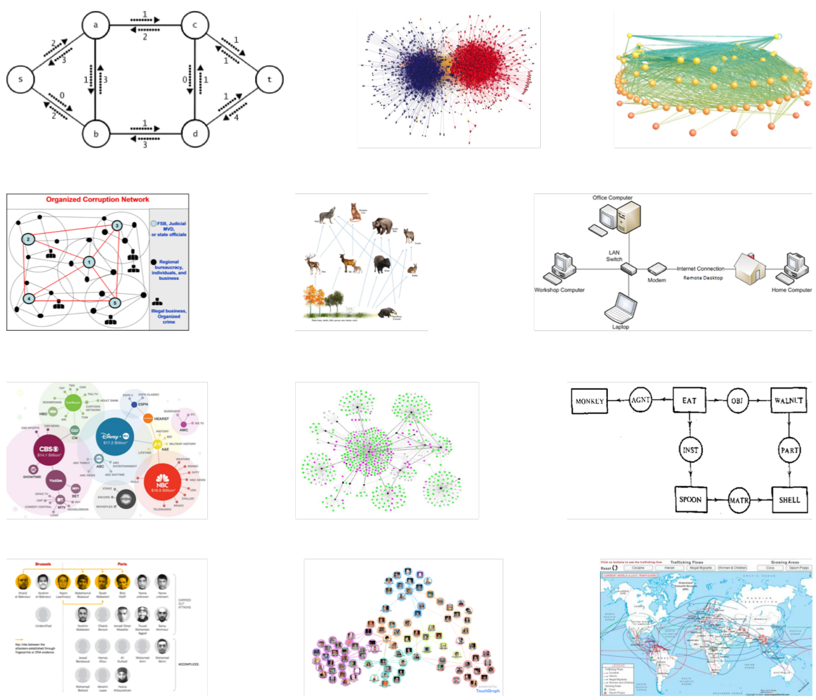


Fig. 7. Visual representations (maps) of network theory analyses

Figure 7 illustrates the ubiquity of uses of network theory. There are countless kinds of networks from (top to bottom left to right): abstract, political voting, food webs, terrorist, ecological, computer, company, dating, linguistic, crime, social, or human trafficking.

The origin of network theory (a.k.a. graph theory) can be traced to 1735 when the Swiss mathematician, Leonard Euler solved the problem of the seven bridges of Königsberg (33, 34). The problem was to devise a walk through the city of Königsberg, Prussia (now Kaliningrad, Russia), which includes two large islands connected to the mainland by seven bridges (Figure 8a), that would cross each bridge once and only once. To solve this problem, Euler reduced the complexity of the problem to only the elemental nodes or vertices (the land masses) and edges (the bridges). This solution gave rise to network theory, which is at its essence, an interdisciplinary tool to understand complex systems in a visual way.

Fig. 8. The seven bridges of Königsberg problem

In simple terms, Euler's Network Theory showed that the nodes in a system can or cannot be connected by edges (Figure 8b) (35). From kinship to the chemical composition of all the elements in the periodic table, the simple node-edge construction of the Network Theory provides us with a powerful visual-mathematical abstraction capable of capturing all kinds of relationships, connections, and interactions among nodes in any system (6) (as seen in Figure 9).

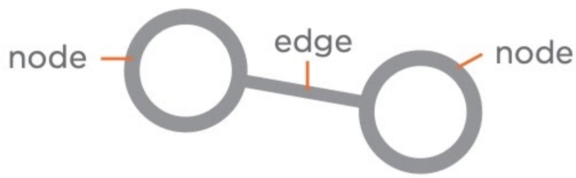


Fig. 9. Basic Structure of Networks (Nodes can or cannot be connected by edges)

From these three examples (Feynman diagrams, structural equations and networks) we can see that systems mapping has radically changed these disciplines, which in turn have shown us that the application of systems mapping is unlimited. For instance, in recent years, researchers have used visual mapping to better understand the complexities of self-identity, recognize the complex nature of contemporary lived reality, and create opportunities to speak across different ethnic identities (36).

The "little pictures" that changed these fields are exemplars of the potential to change any field. In other words, the little pictures themselves are merely the manifestations of something deeper. Something more structural and invisible—like the bulk of an iceberg lying beneath the surface. What lies underneath these "little pictures" is a powerful and transformative cognitive architecture. Usually simple yet sublime, it is this deep understanding of the underlying structure of the universe that makes these little pictures so powerful. Underlying all knowledge there is a universal cognitive grammar (UCG) called DSRP. It is this UCG that makes the difference between systems mapping that is "little pictures" and systems mapping that is truly transformative.

Thus far, we have discussed how and why systems mapping must fundamentally be visual, tactile, object-oriented, and social. That is, *systems mapping* must be *multisensorial mapping* rather than merely *visual mapping*. In this case, when we say multisensorial we mean that it is not only (1) visual, (2) tactile, (3) object-oriented, and (4) social, but that these four modalities are inseparable or intersectional. They occur together and due to their dynamical interaction, they sum to greater than the four alone. The idea of image-ination or mental imagery however, provides us insight into the need for a 5th principle of systems mapping: the underlying cognitive grammar of the mapping itself.

3. From Visual Mapping to Multisensorial Mapping based on a Universal Cognitive Grammar

The notion that our body influences our mind is known as embodied cognition, and, surprisingly, it is a relatively new idea dating back to the early 20th century. Previously, the prevalent notion was that of the disembodied mind, derived from Descartes's theory of dualism that suggested that the mind and body are distinct and separable (37, 38). Philosophers Martin Heidegger, Maurice Merleau-Ponty, and John Dewey were the first to see our bodily experience as the primal basis for all we know, think, and communicate (38, 39). It was not until the 60s and 70s, however, that scientists began conducting empirical studies on embodied cognition (38).

George Lakoff, a professor of linguistics at the University of California at Berkeley, and Mark Johnson, a professor of philosophy at the University of Oregon, are two of the most influential theorists of embodied cognition. In their book Philosophy in the Flesh: The Embodied Mind and Its Challenges to Western Thought, they explain:

> "Reason is not disembodied, as the tradition has largely held, but arises from the nature of our brains, bodies, and bodily experience. This is not just the innocuous and obvious claim that we need a body to reason; rather, **it is**

> **the striking claim that the very structure of reason itself comes from the details of our embodiment...** Reason is shaped crucially by the peculiarities of our human bodies, by the remarkable details of the neural structure of our brains, and by the specifics of our everyday functioning in the world (emphasis added) (39)."

Furthermore, Lakoff and Johnson expound that reason is mostly unconscious, largely metaphorical and imaginative, and emotionally engaged (39). They coined the term **conceptual metaphors**, which are metaphors in which one idea is understood in terms of another (40, 41). To show this, they ask us to think of the concept "argument" and the conceptual metaphor "argument is war (40)." They provide various examples of how this conceptual metaphor is reflected in our language: "Your claims are *indefensible*." "His criticisms were *right on target*." "I've never *won* an argument with him (40)." Lakoff and Johnson also point out that besides *talking* about arguments in terms of war, the things we *do* in arguing are also partially structured by the concept of war (e.g., we attack, defend, or counterattack).

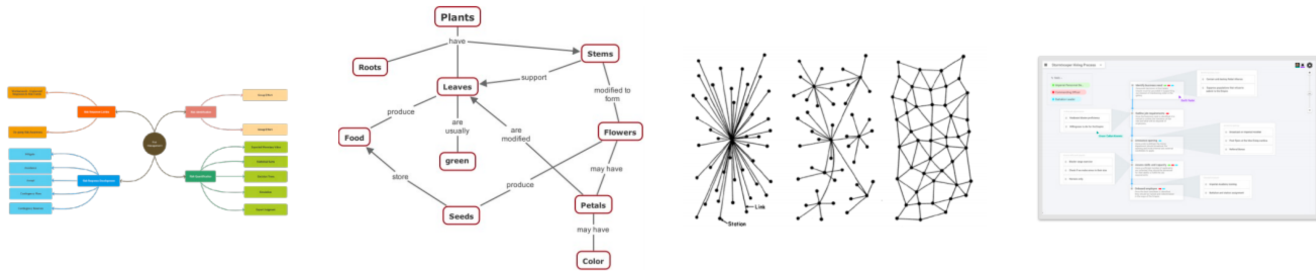
Other conceptual metaphors are: Affection is Warmth ("They greeted me *warmly*"), Important is Big ("Tomorrow is a *big* day"), Happy is Up ("I'm feeling *up* today"), and Bad is Stinky ("This movie *stinks*") (39). Researchers have empirically tested these ideas. Yale researchers, for example, found that persons holding warm coffee were more likely to evaluate an imaginary individual as friendly and warm than those persons holding cold coffee (42). Similarly, at the University of Toronto, researchers asked subjects to remember a time when they were either socially accepted or socially rejected. Those with warm memories of acceptance judged the room to be five degrees warmer, on average, than those who remembered being coldly ignored (42). These studies show that there is a direct connection between our physical sensations and our conceptual understanding of the world. Lakoff's and Johnson's identification of conceptual metaphors is germain to Systems Mapping in two important ways. First, it illustrates that when we use the term "visual mapping" as shorthand for systems mapping, it is something of a conceptual metaphor—one that is multisensorial in nature. In other words, we do not literally mean that it is merely visual. Systems mapping is visual, tactile, object-oriented, social, and most of all, it is embodied. The second aspect deals with this embodiment, which is critically important. Systems mapping—in order to be effective—must be embodied. In other words, it must be based upon structures that exist both materially in the physical real-world as well as materially in the cognitive or conceptual world of mental models. Only then can it be used for the embodiment of mental models in reality (through some translatory structures that are shared in both realms: i.e., DSRP). As we will see, systems mapping that is undergirded by an architecture of DSRP provides this required embodiment. While this does not mean that our mental models of reality will always be "right" (they won't, in fact they are always "wrong" because they are merely approximations of reality), it does mean that we can increase the probability that they are "righter" and also that they get "righter" incrementally over time. The reason for this is that there can be a 1-to-1 correspondence between reality and our mental models.

Other studies mapped neural connectivity to understand the relationship between our brains and body. Cortex Man or *cortical homunculus* is a representational model of the human body from the perspective of the human mind and its mapped neural connectivity (43). The model (in Figure 10) shows the massive role that the hands, mouth, eyes, nose, and ears play in both the sensory and motor cortex. Cortex Man shows that humans understand the world through their senses, and thus proves the importance of visual diagramming and tactile manipulation in the learning and knowledge-building processes. Knowledge-building is multisensorial. The brain is multisensorial. Visual Mapping is multisensorial. Systems Mapping is multisensorial.

Fig. 10. Cortical homunculus - aka, Cortex Man

A. Not All Visual Maps Are the Same So far, we have learned why visual mapping is so critically important to understand the world. "But, not all visual maps are created equal (44)." Some maps are more in alignment with real-world complexities and the way our brains process information (44). The best visual maps help us align our ideas with real-world phenomena and avoid oversimplification of complex problems. Mindmaps, concept maps, network maps, and DSRP network maps are among the most popular approaches to visual mapping. Tony Buzan's **mindmaps** rely on the assumption that the underlying structure of human thought is radial. Joseph Novak's **concept maps** have a hierarchically- and relationally-based architecture.

Euler's network maps are constructed using nodes and edges. Finally, Cabrera's **DSRP network maps** are built by making distinctions, identifying parts and wholes, recognizing relationships, and taking perspectives (as shown in Figure 11) (44).



a) A Buzanian mind map based on centralized, radial part-whole architecture

b) Novakian concept map based on hierarchical, concept + linking words architecture

c) Network maps based on a node + edge architecture

d) dsrp-network maps based on recombinant distinctions, part-whole, relationships, and perspectives architecture

Fig. 11. Different types of "systems maps"

DSRP cognitive theory provides the four simple rules that underlie our thinking:

1. **Distinctions Rul**e: Any idea or thing can be distinguished from the other ideas or things.
2. **Systems Rule**: Any idea or thing can be split into parts or lumped into a whole.
3. **Relationships Rule**: Any idea or thing can relate to other ideas or things.
4. **Perspectives Rule**: Any idea can be the point or the view of a perspective.

An implicit "fifth rule" is that these four rules can be combined and recombined in any order in an infinite number of ways to create new knowledge (44). A thing or idea can simultaneously be a distinct entity, a perspective, a part of a larger whole, a whole made up of smaller pieces, and a relationship (6). This process of distinguishing ideas, grouping and ungrouping them, relating them, and seeing them from different perspectives is the universal cognitive process for human thought and knowledge creation. DSRP's modular, fractal, adaptive, and network structure mimics real-world structures, and therefore it bridges the conceptual and the real worlds. DSRP is a physical-conceptual bridge theory. It bridges the material worlds of physics, chemistry and natural sciences, with the material-conceptual world of psychological and sociological sciences.

This is critically important to understanding the potential contribution of DSRP Theory. It is, as Cabrera states, "a theory of thinking and a theory of things"(6, 10, 45–55). DSRP is not merely a set of simple rules for cognition or conceptualizing. It is—as Lakoff and Johnson proclaim—"[the striking claim that] the very structure of reason itself comes from the details of our embodiment." DSRP provides the structure of this reasoning and of physical embodiment itself. D, S, R, and P are not merely cognitive operations; they are conceptual metaphors of real-world, physical, material, embodiment that have pressed themselves evolutionarily into our cognition, conation, and emotion. All ideas and things have boundaries. All ideas and things have part-whole structures. All ideas and things are relational. And all ideas and things are perspectival. In terms of the conceptual metaphors Lakoff and Johnson describe, DSRP provides the most basal, universal, essential, and embodied conceptual metaphors in the universe: D, S, R, and P. (See Table 1).

Structural Patterns	**Co-implying Elements**		
Distinctions (D)	identity (i)	$\leftrightarrow$	other (o)
Systems (S)	part (p)	$\leftrightarrow$	whole (w)
Relationships (R)	action (a)	$\leftrightarrow$	reaction (r)
Perspectives (P)	point (ρ)	$\leftrightarrow$	view (v)

Table 1. Universal Physico-Cognitive Structural Patterns and Their Co-implying Elements

Thus, if we understand the cognitive architecture of DSRP for whatever application and instantiation we choose, we are going to have a better and fuller understanding of the world. To illustrate this, we will present the 5 steps to Systems Mapping and two case studies that use DSRP mapping to analyze two complex social, political, and legal issues.

B. 5 Steps to Systems Mapping Let's take a look at a very practical example of how one might use DSRP as a stepwise mapping process.

We know that we build meaning from information - through structural thinking and its application. First take whatever information source or sources you have. These could be a single article, a book, a report, many reports, interviews, anecdotal evidence, or any other kind of information. We will follow these 5 steps (Figure 12) as we map this information to form a meaningful mental model:

1. Start with a “Splat Map” of distinctions onto the canvas as you read;
2. Organize them into obvious part-whole systems;
3. Consider the salient relationships that may exist at top level mental model;
4. Zoom further in to Relate the parts at level 2; and
5. Look at all of this from different perspectives...(Do as many second order perspectives as needed).

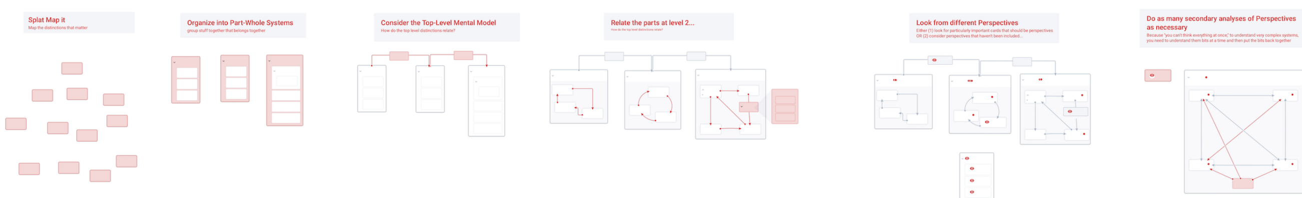


Fig. 12. Steps to Mapping

We then distill it all by zeroing in on the salient distinctions, relationships, systems and perspectives that help one understand the dynamics of the system. Note that we can also build new ideas as they come and refine layout for clarity.

Step 1-Splat Map It: Map the Distinctions that Matter. Everything needs to be included - all the relevant ideas. Much like post-its on a wall or a whiteboard - getting these ideas out of your head helps to understand them better. ALL we are doing here is making the distinctions that make up the system. Just lay them out randomly on a board using either a computer program, post it notes, drawing rectangles on a board or piece of paper, or physically arranging some representative objects as shown below in Figure 13.

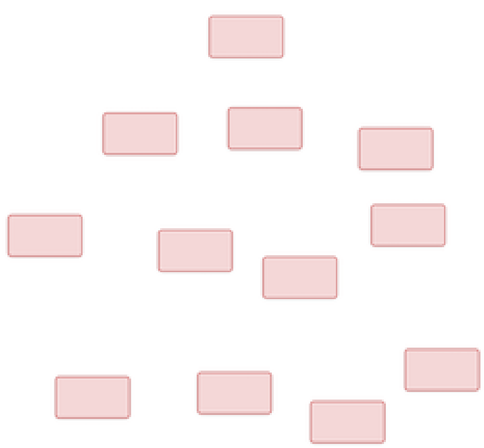


Fig. 13. Step 1

Step 2- Group stuff together that belongs together: In order to start to make sense of all of these things in our splat map we begin to group things that belong together which comes naturally. So in this step we are organizing all these distinctions from our splat map into meaningful groups shown in Figure 14.

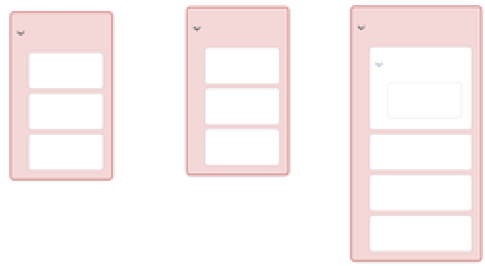


Fig. 14. Step 2

Step 3-Consider the Top-Level Mental Model: How do the top level distinctions relate? Now that we have identified all of our sub-systems within this case, the next step is to identify the key relationships (shown by red boxes) between and among them (Figure 15). This provides meaning at the top level of how the major systems interact with each other. Note that any of those relationships could be a cycle, a linear process, etc.

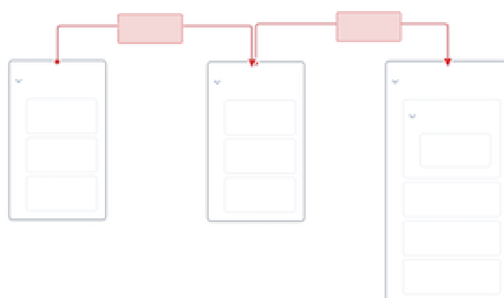


Fig. 15. Step 3

Step 4-Relate the parts at level 2: Ask yourself, how do the next level of distinctions relate? These top level relationships are more obvious and general, so to truly understand the dynamics in this system, we need to drill down to the next level of ideas and examine the relationships among them. Specifically, the bottom box depicts a 3 part system, and we therefore should question if there are relationships between them, as shown in Figure 16. You see that the relationships among the parts are explicated.

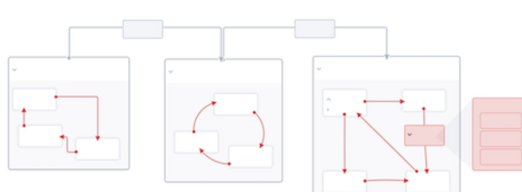


Fig. 16. Step 4

Step 5-Look from different Perspectives: In Step 5, (1) look for important cards that should be perspectives or (2) consider perspectives that haven't been included (Figure 17). We've done a splat map, organized them into systems, and identified relationships, now we need to look at this from different perspectives to deepen our understanding of this complex system. Note we want to take perspectives that are both human (anthropomorphic) and conceptual. Inside the system, and also ON the entire system.And are there ANY perspectives that haven't been considered?

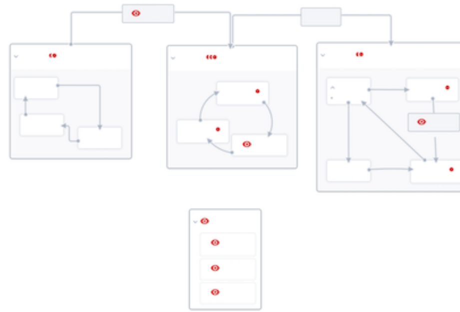


Fig. 17. Step 5

As a substep to this step, do as many secondary analyses of Perspectives as needed. Because you can't think everything at once, to understand very complex systems you need to start with bits at a time and then put them back together. And, if there is a node that appears to be more significant than the others, take the time to do a secondary analysis of the larger system from that node's perspective. This is not merely an exercise, it is a powerful way to partition out salient variables or factors in a system, turn them into a perspective to deeply understand not only their role INSIDE the system, but as an external lens ON the system to uncover an approach that will have high impact on the issue at hand.

And, note you can do this process with any perspectives needed. Indeed, over time you may develop a reusable list of perspectives that apply to most systems such as: Technological, Historical, Social, Health & Safety, Political, Emotional, Moral/Ethical, Security, Ecological, Cultural, Legal, Organizational, and Economic. Each one of these perspectives (and many many more) could be used to look at any given system in a new light as shown structurally in Figure 18.

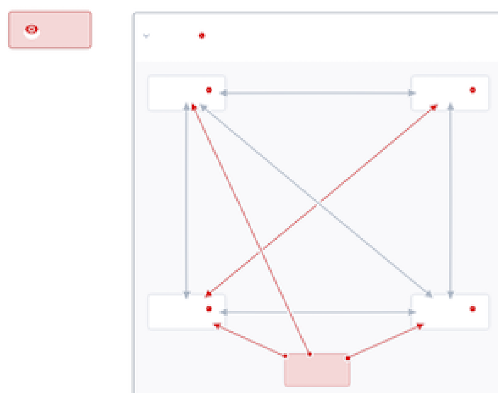


Fig. 18. Step 5a

4. Case Studies in Systems Mapping

A. Case Study 1: Systems Mapping for Policymaking: Indigenous Women in Mexico Lucio Maymon (2018) used systems mapping to understand why indigenous women in Mexico suffer systematic and widespread human rights violations and to draft a policy proposal to address this issue (56). Her research and findings provided the basis for her master's thesis in which she analyzed the United Nations Convention on the Elimination of all Forms of Discrimination Against Women (CEDAW) with an intersectional perspective as a legal, political, and advocacy tool to protect indigenous women's rights (57).

You are probably wondering how an international treaty, indigenous women, and Mexico are related to systems mapping? The answer is that systems mapping enabled Lucio to analyze better and understand the wicked problem[§], which involves many actors, multiple agendas, intricate power relations, and countless perspectives. With the help of systems mapping, she made clear distinctions, identified the various parts of a complex system, understood the relationships underlying the system, and adopted different perspectives to understand the problem at hand.

A.1. Making Distinctions: Who Are Indigenous Peoples? In an attempt to distinguish her study subject, Lucio discovered that there is no universally accepted definition (distinction) of indigenous peoples. Instead, every society, country, and organization has adopted an identification approach based on some of the following criteria: self-identification; historical continuity with pre-colonial societies; a strong link to territories and resources; distinct social, economic and political systems; distinct language,

[§] Wicked problems are complex problems that involve interlinked issues, multiple agencies, different views on the problem and potential solutions, varied power relations, and uncertainty about the possible outcomes of action (6) culture and beliefs; and a resolve to maintain and reproduce their ancestral environments and systems as distinctive peoples and communities (58).

Given the diversity of indigenous peoples worldwide, it is understandable that the international community has not adopted a definition. Nonetheless, the lack of a homologized method for identifying indigenous peoples creates several political, social, and legal issues. In Mexico, for example, three federal institutions compile data on the country's indigenous population[¶]. And, because each of these institutions utilizes different criteria, the official numbers of indigenous people in the country vary by millions of people (57).

This realization—which arises from a simple question of distinction making—raised dozens of questions that she was initially overlooking. For example, how can the government design policies aimed at protecting indigenous peoples' rights if they do not know who they are? What happens to the millions of persons who are not accounted for by policymaking institutions? If Lucio had not used DSRP thinking and mapping, she would have likely missed that indigenous peoples have been sidelined from the public agenda partly because there isn't a clear understanding of who they are.

Figure 19 shows how Lucio used DSRP structural analysis to understand the issue at hand. Structurally, Lucio's premise was that the failure to (1) make advanced and clear distinctions, (2) identify the parts of a complex system, (3) understand the relationships underlying the system, and (4) adopt different perspectives before the implementation of legislation leads to harmful unintended consequences. Specifically, her hypothesis was that the Mexican government failed to (1) make a clear distinction of indigenous peoples in the country, (2) protect indigenous women as members of indigenous communities, (3) understand the unique relationships and patterns of discrimination experienced by indigenous women, and (4) adopt different perspectives towards the issue of indigenous peoples' rights. These failures led to human rights violations against indigenous women.

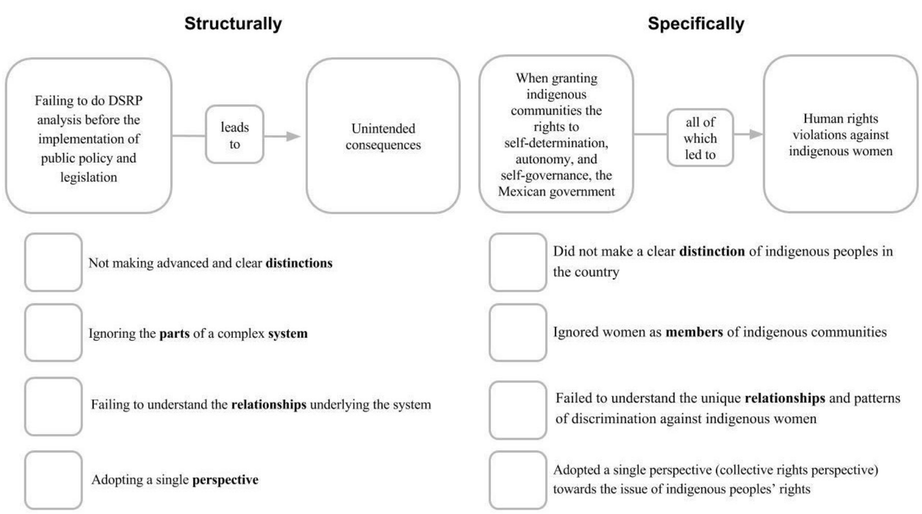


Fig. 19. Structural and specific analysis of the problem

A.2. Complex Problems Call for Complex Solutions Through DSRP mapping, Lucio was able to visualize that indigenous women are part of numerous larger systems, including their family, community, political group, municipality, and nation. At the same time, the collective body of indigenous women is in itself a system made up of millions of individuals with different identities based on their gender, age, ethnicity, race, religion, marital status, sexual orientation, and socioeconomic status. Further, indigenous women—as individuals and as a group—do not exist in a vacuum but are interrelated to other actors. These actors, as Figure 20 shows, include the government, their community, and society in general.

[¶] The National Population Council (CONAPO), the National Commission for the Development of Indigenous Groups (CDI), and the National Institute of Statistics and Geography (INEGI) (57)

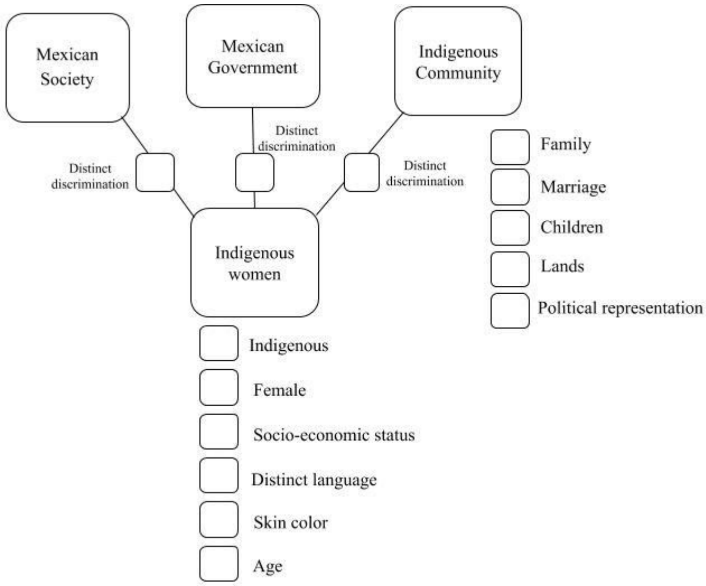


Fig. 20. This map shows some of the relationships and part/whole systems that shape indigenous women's lives.

Because indigenous women are discriminated against both inside and outside their communities, and as a result of their intersecting identities, their rights must be defended at different levels and through varied strategies. Thus, guidelines and recommendations to be implemented at the local, national, and international levels were identified. This work relied on an intersectional perspective that involved examining the gaps in the legal and social recognition of indigenous women who exist at the intersection of multiple identities (57, 59). In sum, DSRP mapping helped visualize the complexity of the problem that led to a multifaceted proposal to promote the fundamental rights of indigenous women in Mexico. Without systems thinking and mapping, Lucio's thesis would have been more superficial, less inclusive, and oversimplified. Predictably, she continues to identify new distinctions, relationships, systems, and perspectives that she initially failed to consider. Nevertheless, the goal of systems mapping is precisely to continually adapt and approximate our mental models to reality. Systems mapping is a powerful tool to visualize wicked problems and to create effective, complex, dynamic, and multivalent solutions (6).

B. Case Study 2: Systems Mapping for Enfranchising Foreign Nationals in the United States The second case study focuses on the right of suffrage of residents of the United States who are not American citizens, or "Shosics" as Castellanos-Canales labels them (60). The study of Shosic enfranchisement is a complex system of ideas that involved a wide variety of legal, philosophical, and historical theories. To ponder whether Shosics should have the right of suffrage, Castellanos-Canales searched for judicial resolutions, foreign legislation, international treaties and jurisprudence, historical documents, philosophical theories, and an endless list of literature on the subject matter. Writing a dissertation felt like a fight against the mythological Hydra. Every time Castellanos-Canales seemed to have covered one topic, ten new issues would emerge. To effectively address the multidisciplinarity of his research, Castellanos-Canales adopted a systems mapping approach that followed a DSRP methodology (6). This systems thinking approach allowed Castellanos-Canales to narrow the scope of his dissertation and lay an effective plan for his research. Systems Thinking facilitated the identification of exhaustive distinctions in the American electoral system as explained below.

B.1. Making Distinctions: Problematic Labels and Multiple Electoral Jurisdictions When Castellanos-Canales started his research, he first noticed the multiple and inconsistent labels used to refer to the 22.6 million residents of the United States who are not American citizens (61) including: aliens, immigrants, foreign nationals, expatriates, and non-citizens. Those labels not only perpetuate the stereotypes and negative connotations of this group of people, but are also inaccurate and confusing.

The label *alien* is demoralizing. "An alien is someone from another planet. Someone that is not even human (62)." The term *immigrant* is not wrong, but it is not precise either. Every noncitizen is an immigrant, but not every immigrant is a noncitizen. Immigrants who become naturalized American citizens will always be immigrants regardless of their new citizenship status. The labels *foreign national* and *expatriate* are only appropriate when nationality is an essential suffrage qualification. Castellanos-Canales highlighted, however, that there are multiple electoral jurisdictions in the United States—such as school district elections, library district elections, village elections, town elections, city elections, and state elections—where the nationality of a voter is an irrelevant trait. Finally, Castellanos-Canales also refrained from employing the label *noncitizens* because it perpetuates a negative connotation and creates unnecessary confusion. When we label a concept for what it is not, Castellanos-Canales argues, we hinder expressiveness, vocabulary, and comprehension (60). See Figure 21.

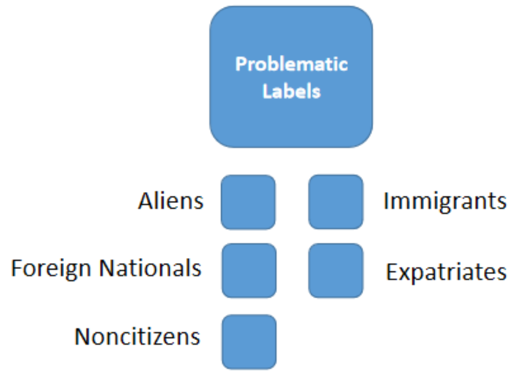


Fig. 21. Systems Mapping of Problematic Labels

Therefore, Castellanos-Canales, created a new, precise, appropriate, and well-rounded label for residents of the United States who are not American citizens: *Shosics*. The word *Shosic*, as explained in Castellanos-Canales's dissertation is a semi-acronym for the Latin *suffragio et honorum sine civitas* or suffrage and office-holding without citizenship (60).

B.2. Additional Distinctions: Who Are Shosics in the United States? All these problematic labels—and the stereotypes that they reinforce—represented the first problem to Shosic enfranchisement. Democratic policies and electoral laws in the United States seemed to be influenced by negative preconceptions of this group of people. Some American citizens and public officials, Castellanos-Canales discovered, are opposed to the suffrage of Shosics because of the mistaken, implicit bias that they are low wage, uneducated, rural immigrants who do not speak English and who do not have enough knowledge on American civics and history. Nevertheless, that is not necessarily the case.

Systems mapping revealed that there is a lot of diversity among Shosics. As seen in the Figure 22, the U.S. attracts students, professors, doctors, farmworkers, entrepreneurs, domestic workers, artists, caretakers, and a host of talent from all over the world. Some of them came to the United States because they are world authorities in their respective fields, while others escaped from their countries to save their lives. Some immigrated to the United States from developed countries while others fled developing economies. Some are very well-off, while others strive every day to make ends meet. Shosics form a diverse group of people, and thanks to systems mapping (60), Castellanos-Canales was able to appreciate this diversity fully.

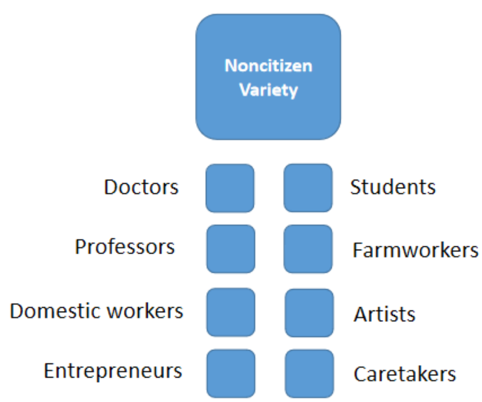


Fig. 22. Systems Mapping of Noncitizen Variety

After seeing all the diversity, and to systematize his analysis, Castellanos-Canales classified all Shosics of the United States into two different categories: (1) documented Shosics and (2) undocumented Shosics. To better approximate his thesis to the real world, he further subclassified these groups as shown in Figure 23:

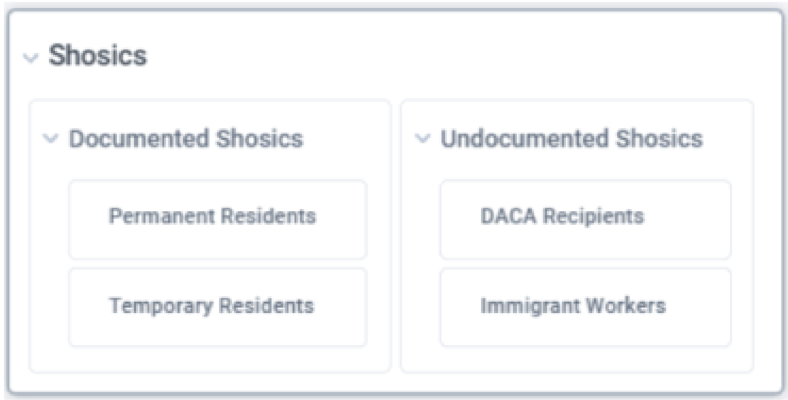


Fig. 23. Systems Mapping of Residents of the United States who are not U.S. Citizens

Using these classifications, Castellanos-Canales was able to address the different categories of Shosics and provide tailored arguments for each. Thanks to the clear distinctions and relationships that he discovered, Castellanos-Canales understood better and, hence, explained better Shosic enfranchisement. Systems mapping allowed for a more effective and assertive plan articulated in his doctoral dissertation.

5. The Future of Systems Mapping

Note that in both of these case studies, DSRP Mapping (mapping of one's thinking) directly applied to the actual, real-world, physical, material, phenomena. The struggle was to get these two worlds (the real-world and one's conceptual world) into alignment. Because the DSRP Mapping Language "maps" to both worlds, it is a translatory device between worlds. One cannot say the same for other forms of rationality and logic. For example, strictly binary logic often fails us in the real world. Predicate logic, for example, often fails us. An economic rationality form of logic, often fails us in the complex world of human decision making and behavior. The logic of DSRP provides a bridge between the cognitive and physical worlds and is therefore an ideally suited tool for Systems Mapping. Note, for example that each case involved differing distinctions, some which contravert the data of real-world distinctions. Hierarchical part-whole structure abounds—some of this structure real, and some a figment of our collective imagination. Relationships are pervasive throughout—some spurious, some real, some explicated, others ignored. New perspectives drag in new complexity, illustrating precisely why reality is complex and multivalent.

And note too, that while many of the dilemmas discussed in the cases may seem "abstract" or "conceptual" (what is a Shosic? who is indigenous?) they are also robust, tangible, physical realities (an individual with a name, an identity, and perspective, a life, a family, is being ignored, oppressed, etc. based on these "abstractions").

Mapping systems require a *translatory language* that allows us to map across two seemingly incommensurate domains: reality and our mental models (not to mention the scientific domains: psychological, cognitive and sociological sciences; and the physical, chemical, and natural sciences). The goal is to adequately map one domain onto the other. The result is a map that we know is not the territory, but is at least a good rendition of the territory, that can be used to adequately navigate it without getting lost.

In an era where we have instant access to an infinite amount of information and where humans are as interconnected as ever, it is crucial to learn how to effectively and consciously map our knowledge. Unlimited access to data can be a blessing, but it can also be perilous if we do not distinguish between the relevant and the irrelevant, and between the true and the fake. Systems mapping, regardless of its instantiation, offers a universal grammar for human thought that can help humans adapt to the information age (6). Systems mapping therefore has the potential to help everyone, from advanced scientists to children, effectively filter, understand, and share their knowledge.

Systems mapping in the future will continue to be a knowledge-simplification tool as it has for the past centuries. Nevertheless, the new challenge for systems mapping tools and software is to develop universally accessible designs (63). Successful mapping platforms will be those that are usable by a wide variety of people including those with disabilities. Instead of focusing exclusively on visual learning, systems mappers must offer designs that take into consideration the needs of people with sensory disabilities. Tools and software that enable users to systems map with minimal effort and to achieve their goals successfully will become the dominant players of the market. Educators and managers who use systems mapping tools and strategies will be the most successful.

A. Instantiations of UCG in Systems Mapping In this chapter, we have laid out some important ideas about systems mapping. Systems Mapping is at its core the basis of the ST/DSRP Loop (Figure 24, which explicates that we must iteratively build mental models to develop better approximations of reality. In its abstraction, this is a form of "mapping" where one domain is mapped upon another. This is similar to when any mathematical or translatory mapping occurs between domains (which often are structured differently with different grammars, syntax, etc), a device is necessary. In this sense, DSRP provides a structural basis for deep questions about how we map our systems thinking onto systems.

DSRP also provides a structural algorithm for deep questions about "systems mapping" at the *operational* level, by elucidating the cognitive style(64) that guides us and the often-invisible cognitive architectures that inform us (for example those used in determining how information must be structured on the internet, how Powerpoint software should be designed, etc.).

But we are also talking about "systems mapping" at the *tactical* level. Is scribbling on a napkin systems mapping? Is building a LEGO a form of systems mapping? Do I use post-its or sugar packets? Software, whiteboard, or paper? All of these are tactical considerations for systems mapping.

This paper portends that Systems Mapping is multisensorial-especially visual/spatial, tactile, social, and object-oriented. It is borne of thinking that is also visual, tactile, and object-oriented (DSRP). In other words, if we are to look at something and ask ourselves whether it is Systems Mapping, we must think more deeply about what elements we would be looking to for confirmation. Systems Mapping derives from Systems Thinking which necessitates that it utilize a cognitive architecture (a universal cognitive grammar or UCG) that bridges the physical and cognitive systems. There is ample evidence that DSRP does this (45), thereby increasing the probability of a match between mental models and real-world systems (See Figure 24).

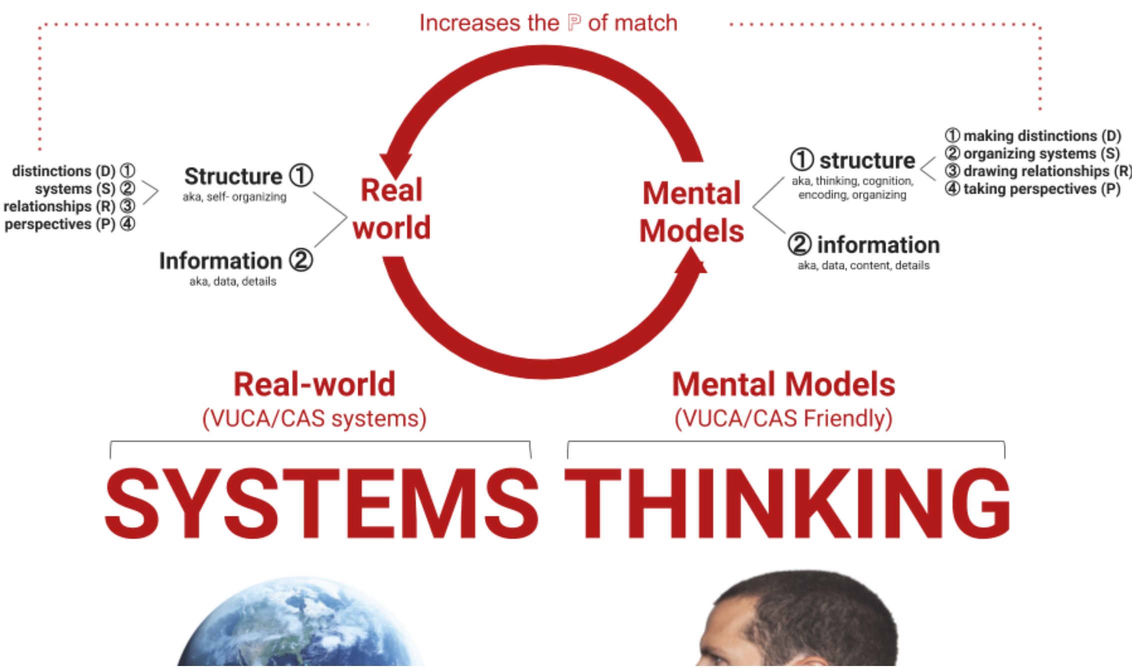


Fig. 24. The ST/DSRP Loop

How can we be better systems mappers? Appendix A identifies a comprehensive list of specific things that any good Systems Mapping Application should have regardless of the medium chosen. To simplify this process, however, we have created a ten-step checklist that can help you assess the effectiveness of your map, whether you are using Post-it notes, clay, software, or napkins.

1. Distinguishing
    - Are my distinctions MECE/NONG (Mutually Exclusive Collectively Exhaustive / No Overlaps, No Gaps)?
    - Are my distinctions necessary/sufficient?
    - From what perspective (set of assumptions) am I making my initial distinctions?
    - Am I othering (Creating a marginalized other)? Could things be distinguished differently?
2. Systematizing
    - How are things organized into part-whole groupings/systems?
    - From what perspective are my groupings being made? Could things be organized differently? Am I locked into categorical thinking?
3. Relating

- Have the parts of systems and subsystems been sufficiently related?
- Do any of the current relationships need to be distinguished? Systematized? (RDS)

4. Perspectivizing
   - What perspective is the whole system from? Am I okay with that?
   - Is there anything in the system analysis that should be a perspective on the whole?
   - Are there /missing/important perspectives that would provide insight?
   - Are all of my perspectives "with eyes"?

B. A Rubric for Future of Systems Mapping and Its Applications If we are to meet the future of systems mapping and it's potential we must keep two things in mind.

Systems mapping is best when it is visual, tactile, social, and object oriented. This is because of how our human brains are wired. In other words, "if we were developing systems applications for dogs rather than humans we would want it to be based on hearing and smelling. Because we are human we are best served when it is based on seeing and touching.

The key to systems mapping is a powerful universal cognitive grammar (UCG) like DSRP (45).

Inasmuch, there are many advancements that can be made in the visual and tactile medium we choose to use and the techniques we employ. Techniques on a broad spectrum including: individual visualization and manipulation of ideas in the mind (cognition); hand drawing; note taking; white or blackboarding, various subsequent visual mappings in the disciplines (Such as Feynman diagrams or structural formula); tactile manipulatives (formal or informal); digital manipulatives; software, etc. What we can call collectively, "Systems Mapping Applications." In The Cognitive Style of PowerPoint: Pitching Out Corrupts Within, Edward Tufte (64) describes the cognitive architecture or "style" of PowerPoint. He shows that this cognitive style can lead people to misunderstand, miscommunicate, mis-act, and mislead, resulting in numerous negative knock-on effects. One can imagine that, if a faulty *cognitive style* can be the culprit to all of these misdeeds, then a well-designed cognitive style could also result in lead people to understanding, communication, right-action, and leadership. Thus, the question we must be asking ourselves is less about which medium or application of Systems Mapping we should develop, but *what is the cognitive architecture for Systems Mapping Applications writ large?* This paper and previous research has answered this question: DSRP structures provide a UCG for Systems Mapping Applications. But, for the field of Systems Mapping to truly be charted for the future, the subsequent question we must answer is this:

What are the basal functions that must be in place to constitute a Systems Mapping Application?

To answer this question we provide in Rubric below entitled, "Necessary and Sufficient Systems Mapping Features Scoring Rubric" (see Table 2). This Rubric provides a listing of the basal features that can be derived from the simple rules of DSRP and that should be—at a minimum—present in any Systems Mapping Application. The Rubric is broken into 5 sections numbered 1-4 and includes:

1. **Dio Section 1**: Includes specific features having to do with making identity (i) / other (o) Distinctions making (Dio)
2. **Spw Section 2**: Includes specific features having to do with organizing part (p) / whole (w) Systems (Spw)
3. **Rar Section 3**: Includes specific features having to do with drawing action (a) / reaction (r) Relationships (Rar)
4. **Pρv Section 4**: Includes specific features having to do with taking point (ρ) / view (v) Perspectives (Pρv)

Table 2. Necessary and Sufficient Systems Mapping Features Scoring Rubric.

#	Systemic Feature (symbols)	Description	To Achieve a 1 Rating you must:	To Achieve a 2 Rating you must:	To Achieve a 3 Rating you must:	To Achieve a 4 Rating you must:	Combined Points	Subtotal
1	D: Di; Dio; D-counts; Di-definition; Fractal-D	Features having to do with capturing, facilitating, motivating, and predicting distinguishing structures. Provides levels of distinction making, labeling, identification, and definition.	Di: Distinction (identity only); The ability to identify objects (cards, shapes, etc) and label them.	Di: Distinction (identity only); All of 1 + ability to add additional media beyond basic labelling to further distinguish an identity (i.e., images, text, links, video, color, size, shapes, etc)	Dio: Distinction (identity-other); All of 2 + the ability to contrast identities with others (antonym networks, etc); the ability to use and reuse canonical identities across use cases; provides a listing of what item is and is not (e.g., true identity definition); provides a Dio counts by calculating the total number of Di, Do objects in a system	Fractal D: The ability to create identities (cards, shapes etc) at any level anywhere in the map as a universal simple rule/function.	1,2,3,4	10
2	S: Spw; Spw-nesting; S-counts; Fractal-S	Features having to do with capturing, facilitating, motivating, and predicting systemitazing (part-whole) structures. Various features making part-whole nesting, containment and belonging possible.	Spw: (part-whole structure); The ability to create part-whole systems.	Ability to nest part-whole structure to multiple levels (>10). The ability to nest parts inside parts inside parts.	Counts that adequately account for part-whole belonging including counting relational parts; multiple formats for displaying part-whole organization	Fractal S: The ability to create hierarchical structures (part-whole nestedness) at any level anywhere in map as a universal simple rule/function.	1,2,3,4	10
3	R: R-label, no R-confusion; RD-object, RDS, RDSP; Rar, Self-R, R-counting, Fractal R	Features having to do with capturing, facilitating, motivating, and predicting relational structures. Allows relationships between identities, and the ability to distinguish, systematize and perspectivize those relationships.	Can draw lines between objects (R); includes basic features like arrow heads, line color and dash, thickness, etc.; avoids R-line-confusion with part-whole (A condition where relational lines are confused with part-whole belonging/containment)).	Can label relationships (R-labels) and can add an identiy-object (Di) to the relationship in order to create a relational distinction (RD-object).	Can make RDSs and RD-SPs (i.e., the ability to create a systematized set of part-whole identities on a relationship); Self-Rs (i.e., the ability to relate a Di to itself); Rar (e.g., the ability to create action reaction variables at terminal ends of relationships; accurate R-counting (i.e., Rs are counted as part of Ss that contain them).	Fractal Rar throughout at every location and level: The ability to relate anything to anything else at any level anywhere in map as a universal simple rule/function.	1,2,3,4	10
4	P: P-presets; Pv; Ppv; P-transforms; Fractal-P	Features having to do with capturing, facilitating, motivating, and predicting perspectival structures. Allows multiple perspectives and accounts for both the point and view and interaction between them.	P-presets: A feature in which a map can be viewed from different predetermined perspectives (e.g., assignee, scheme, etc). Good for popular perspective view presets but not as adaptive as Ppv.	Ppv: Perspective taking (point and view delineated): The ability to take point-view Perspectives; Perspective annotation: The ability to annotate or describe/distinguish perspectives	P-transforms: Transformational Perspective taking: The ability to see how a map changes from any given identity in the map;	Fractal Ppv: The ability to see the system from any identity/node in the system at any level anywhere in map as a universal simple rule/function.	1,2,3,4	10

The Rubric is broken into 6 basic columns:

1. **Systemic Feature (symbols)**: These are the various names by which specific features of the section can be called. Naming these specific features ensures that the field is collectively talking about the same thing and decreases confusion. Names are derived from specific facets of DSRP.

2. **Description**: A brief description of what is included in the section

3. **To Achieve a 1 Rating you must**: This section explicates the various features which—if included in the Systems Mapping Application—allow the award of a 1 point rating.

4. **To Achieve a 2 Rating you must**: This section explicates the various features which—if included in the Systems Mapping Application—allow the award of a 2 point rating.

5. **To Achieve a 3 Rating you must**: This section explicates the various features which—if included in the Systems Mapping Application—allow the award of a 3 point rating.

6. **To Achieve a 4 Rating you must**: This section explicates the various features which—if included in the Systems Mapping Application—allow the award of a 4 point rating.

The final two columns are for point scoring. They include the "Combined Points" column which shows that anytime an SM application meets the criteria, it receives the points, such that if the application meets the criteria for all for ratings columns it receives $1 + 2 + 3 + 4 = 10$ points for that column. Thus, the total points possible for the entire Rubric is 40. Note that the Rubric is designed to be a minimum-concept for Systems Mapping Applications and there can be many more features imagined—all of which sit atop these basal, foundational features. We do not imagine that this Rubric is the "final word." Instead, the Rubric provides necessary and sufficient foundational features and the initial guide rails for developing improved Systems Mapping Applications.

C. Conclusion To become a mature practice, Systems Mapping requires sstructure. It requires a both a philosophical and theoretical structure and also a tactical cognitive architecture. This paper has presented the five philosophical traits Systems Mapping must aspire to: visual, tactile, object-oriented, social, and embodied. It has also provided a theoretical basis on which to build a UCG for mapping in DSRP Theory. Finally, it has provided a scoring rubric as a tactical tool for developing and improving Systems Mapping tools in the future.

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