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Systems Thinking for Systems Making: Joining Systems of Thought and Action

J.L. Henshaw - sy@synapse9.com

HDS natural systems design science

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Abstract

A common use of systems thinking (ST) is for guiding our practices of systems making (SM). One style of ST for SM centers on making designs with deterministic rules, as in the hard sciences, for guiding engineered applications. Another style mimics natural development, with a process by stepwise learning and improvisation to produce evolving designs; examples including architectural design, scientific research, and the practice of action research (AR). All these use exploratory pathfinding to search for better ways to work with reality, and this is the main subject of the paper. Both deterministic and adaptive ST for SM are widely found in differing roles, each having capabilities the other lacks. I start with simple models, such as step-wise improvisation for adapting recipes when making dinner. Another example is Robert Rosen's model for how scientific and other cultures learn to work with nature, by turning attention back and forth between nature and theory for creating their cultural language. A review of the modern history of the systems sciences, as practices of ST for SM, then further broadens the view and context. That leads to introducing a new paradigm of natural systems thinking (NST), using commitments to critical awareness, emancipation, and methodological pluralism for working with natural systems.

Keywords: systems thinking, systems making, Rosen model, action research, natural systems thinking, pattern language, organizational change, narrative arcs

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Systems Thinking for Systems Making

The story begins with our first learning to work with nature in the ancient past. How crafts originally developed would have been by people finding and passing on their versatile insights on how things work, and ways of sharing the kinds of systems thinking (ST) needed for success in systems making (SM). Showing a novice just the right way to chip a stone, cure leather or cook pigments would pass on those transformative techniques along with the ways of thinking needed to go with them. However that process of learning and teaching complex methods takes place, it seems not to have relied on any expert language for specifying what to do. Rather it must have relied on intuitive direct learning in the process of doing things, passing on ways of discovering the tricks that make nature responsive, without a theory to follow. Over the centuries those otherwise largely unrecorded methods of passing on expert practices of thinking and acting were certainly central to the rise of civilization.

That is a kind of logical speculation, what I call an *implicit finding*. In this case, I'm referring to implied traditions of thinking about complex natural relationships learned and passed down for generations to accomplish the many arts of antiquity. As a precedent for this, the Wikipedia article (2017a) on "systems theory" also mentions ST as dating back to antiquity, saying: "with the Egyptian pyramids, systems thinking can date back to antiquity". The intent here is to use simple models like that to help tell a story that anyone might understand from their own experience, and affirm or question as they read. In any case, I do not mean that people of the remote past used what we now know as systems thinking. Rather, I suggest our current ways of thinking about systems have as long a history as human civilization and are directly connected with our learning to make things.

As societies developed, related expert methods developed into various specializations, producing new divisions of labor. The individuality of early complex societies and their social systems would have emerged as those specializations combined to produce new organization for the whole. Both the development of individual specializations and how they became organized to work together would be passed on mostly by demonstration and practice, shaped by the need for society to work as a whole. Over time, some arts were reduced to rules and definitions, like accounting and navigation, marking a division of labor between abstract ST for making things work, based on rules and definitions, and adaptive ST for making things work when learned by demonstration and practice without a theory.

The modern practices for describing all of nature with abstract theories seem to have come from Greek philosophy, particularly Aristotle, Plato, and other early philosophers attracted to the elegant simplicity of representing nature with theory. Modern scientific theory first developed as “natural philosophy” in the 17th and 18th century from the work of Descartes and Newton among others, later called “physics” as a general way of defining abstract calculations for predictable patterns of nature. In the 19th century, theoretical science broke through with a series of great achievements delivering an economic revolution using a new kind of ST for SM, harnessing heat and electricity combined with many new economic strategies to create a multitude of new forms of industry and wealth.

As the use of abstract ST for physics spread, it was found to also work well for engineering, chemistry, astronomy, and accounting, among other fields, but less well for sciences like biology, medicine, economics, and ecology. For the arts and humanities, it worked rather poorly or not at all, as also for essential crafts such as entrepreneurship and design, which remain largely intuitive. Still by all accounts, the great appeal of controlling nature with fairly simple rules, and driven by economic success, inspired the great machine age of the early 20th century, made in the image of deterministic science (Wilson, Pilgrim, & Tashjian, 1986).

For making a steam engine, a steel building frame, or a propeller, the design is developed to satisfy energy and performance equations that remain unchanged while the work of fabricating the needed materials is improvised. This process characterizes what I call the *deterministic style* of ST for SM, a practice led by following set rules. What I call the *adaptive style* of ST for SM is the opposite, a practice of making designs by exploratory pathfinding and successive adaptation, and is the main subject of the paper. Exploratory design is the normal way of working in business, architecture, and scientific research itself, as well as less formally in politics and working with social and cultural change. The complexly organized natural systems we work within can also be seen to develop by something like exploratory adaptation too, evolving along branching pathways like ecologies, cultures, and the weather as their emerging systems develop. How organisms grow seems to involve both styles of design, combining design with fixed genetic codes and adaptive development too. For human designed systems either can dominate depending on which style one focuses attention on and which for natural causes happens to take the lead.

This paper gives more attention to two particular methods of adaptive ST for SM: action research (AR), first developed by Lewin (1947) for guiding adaptive social change, and pattern language (PL), first developed for architecture by Alexander et al. (1977) and Alexander (1979). The latter has developed for focusing the holistic design purposes of diverse fields. The paper first reviews informal and formal methods of ST for SM then the evolving paradigms of the hard and soft systems sciences as they both attempt to overcome barriers to understanding how to work with reality, and finally suggests ways one might look to nature to better understand our own human story and find better models.

Background on Adaptive ST for SM

Research Method

For this seemingly common but understudied subject of how ST connects to SM, I use an exploratory research method, approaching from multiple directions. For illustration, I use simple or familiar models, data on developing scientific methods, literature references and suggestions for possible new directions. What develops is a broad view of how our mental models and working methods connect, discussing pattern recognition methods which are more of a craft than an abstract science. Pattern recognition is also a craft with scientific validity on which all sciences heavily depend. The aim is to help the reader think scientifically about the range of familiar patterns discussed.

Research of all kinds relies on accumulative exploration in the research process, building on patterns of interest to see where they go. The goal in most scientific fields is for explorations to lead to controlled experiments to settle key questions that others might repeat—and then reporting the results. The explorations recorded here could lead to research experiments, but the focus of my work at this stage is much more on building perspective on the general subject of how ST and SM work together.

Adaptive Systems Thinking and Design

In looking for direct references to the work of others on *adaptive* ST for SM I did not find any general study of it, but using Google Scholar (G. S.) found relevant applications showing its currency: one for managing clinical trials, another for negotiating resource management. More formal methods of adaptive ST for SM, like scientific research, commercial product design, AR and software development methods like SCRUM, appear to all first originate with more informal methods of creative adaptive work, drawing on both recent innovations and ancient methods like for making dinner or tending a fire. Those ancient methods of ST for SM passed on by demonstration and practice would have been part of our widely shared cultural toolkit of reliable ways to make things work, from which later advanced methods would develop. For example, one of the most common strategies for successfully doing things involves pausing regularly to evaluate the progress and make adjustments as the work proceeds. There may be set recipes to follow for some steps, but for most tasks, the majority of work is not in the recipe, and creativity is needed to get even simple rules to work as intended. When cooking a family meal, the cook starts with an idea of what to do and then makes repeated adjustments for available equipment and ingredients, to suit individual tastes, for creative ideas, and to simplify if needed to coordinate and finish in time.

Much the same applies to implementing a business plan. Industry conditions, partner decisions, worker observations, and customer reactions are all unpredictable and affect the course. It is still important to have a plan, but the plan is not something one follows strictly. It mostly serves as a condensation of prior thinking from which one improvises to suit changing conditions and new thinking as it develops. It is usually the initial intent that the plan expresses that makes it an important guide, but how to take the actual steps ahead only becomes known as one does them.

This use of incomplete plans to guide improvisation is also part of the least planned things we do, like making friends or having fun, which usually start with a spontaneous thought or feeling that builds and changes with the growing relationship. The same applies to making one's home or making a place for things in your home. Each starts with an initial image and inspiration that guides the process, serving as a *seed pattern* to get things started and then as a reminder of the real purpose when overcoming challenges. The same applies to a business going about making its place in its community or creating a business culture in which employees feel at home. All of these involve a process of pathfinding guided by an idea for systemic change, taking exploratory steps aiming to end in satisfaction.

For guiding the creation of business products, architectural designs, or guiding multi-stakeholder partnerships for environmental problems, there is a need get quite different ways of thinking about a complex subject to work closely together. The work still originates with and is guided by simple ideas, but needs a more formal process to coordinate the different *intelligences* brought by the diverse people and their differing professional cultures. For example, one's parents tend to have different kinds of intelligence making their partnership uniquely valuable. One sees the difference between conversations with one's mother and father, each centering on what they are individually most alert to and for which they have better answers. It is the same for working in teams of people brought together for their differences, each person's kind of intelligence bringing awareness of kinds of patterns others do not see, and creating a task of making their value available. Great innovations often seem to come from a new form of intelligence about the world, and great cultures organized around different ways of seeing and understanding life. Most professions have ancient ways of thinking giving them special intelligence about the world, too. What people with different intelligences might contribute, however, would frequently be invisible to others. It is both the difficulty of complex teamwork as well as the special opportunity too of course, as combining different intelligences can be highly creative, as one sees in teamwork of all kinds.

What seems needed to allow diverse teams of people to work together seems to be a particular organization that allows them to work both independently and together toward a common purpose, like in a work studio atmosphere. Some way of pausing the work so all can review the varied things the team is doing allows everyone to see where things are going and how pieces all need to fit together. In practice, using cycles of reviews for that kind of complex teamwork often becomes highly refined, developing a creative flow that lets everyone involved then pick up their own work with a shared view of the combined purpose. That elevated state also tends to stay hidden from outside view of course. It happens in the coordination meetings, after which everyone can pick up their work with new insight into the evolving nature of the project and how to proceed with their part.

For complex designs, the most important work tends to be in the earliest phases, when numerous conceptual design directions may be suggested and explored with little cost, and the stakes are highest for getting it right. As complex designs progress, the language of discussion often becomes very conceptual, focusing on a common imaginary model of the brand, the place, or some other critical quality of the vision for the work. That requires speaking of the work in a language of metaphors unique to each project that the whole team needs to understand so each can separately follow the work on the whole team in their minds. To maintain a common vision that way a work team also needs both social and productive chemistry, ideally open to each person's unique contributions.

Prototyping is often needed for key elements, such as making varied models, testing how materials go together, trying out critical parts of new software or getting test kitchen samples. That also applies to presenting test plans to focus groups or in town hall meetings, holding test runs for new plays, trial runs for stump speeches, and so on. The process of experimentation and refinement alternates back and forth as designs develop and continues until the product finally gels, can stand on its own, and fulfills its purpose.

Stepwise Processes

A general rule, like a law of organizational development, is that organizational change needs to start slowly with small steps that build up progressively to bigger steps and then build back down toward the end with progressively smaller steps again, as in a life story arc. It is a universal pattern of rising and falling action on a continuum, generally associated with growth or other kinds of organizational development; I call a *natural crescendo*. Organizational development cannot simply begin with big steps but needs to build up to them. The completion of an organizational development then needs to be approached with progressively smaller finishing steps rather than ceasing abruptly. Development is usually a process of building a system, with the initial steps needing to create the organizational structures that are later filled in. That is how nature builds systems, like how a mature plant develops from the sprouting of a seed initiating the process of growth with small steps which create the structures that build up by bigger steps leading to the small details that result in the matured flowering plant.

That natural crescendo of stepwise development is visible in all kinds of growth in plants and animals, businesses, cultures, and even storms. They all begin their development with a small burst of organization and end it with small finishing details, having a swell of big steps in the middle. It is also seen in the formation of successful complex teamwork mentioned above, a flurry of smaller steps to get the team and the work organized for taking on bigger steps and later turn to completing the small details to bring projects to completion. A normal year or semester of schoolwork starts with small organizing steps that build up to bigger steps and accumulate to become great overall achievements with small finishing details in the end. The same pattern is seen in culture change, whether it is social, political, artistic, or technological, as well as in the organic growth of societies and economies. Even personal relationships tend to start with small steps and then a rush of bigger ones, reaching a climax with smaller steps again. This pattern of accumulating steps needed for organizational change is so broad it seemingly reflects nature's universal design for developments.

The order of the steps in making things is usually important, too. A building first needs foundations before floors and walls and then needs the roof before it is safe to do the interiors and finishes. A business needs to be built in stages, too, from a start-up process that assures the productive use of its seed capital, followed by its periods of immature and then mature growth. That is much like how an organism needs a fertilized egg to begin its immature stage of growth to be followed by its mature stages. Subjects in math need to be taught in order, too, to avoid breaking the chain of concepts that will be needed later. In a group conversation, it may not seem to make much difference who speaks in what order, so long as everyone gets to speak. Conversation is also sequential, though, and appears to change direction with everything said. Learning to recognize natural patterns of accumulative design like these (Henshaw 2015) helps one discover how ST, often quite abstract, needs to connect with SM, which can only work in a way that is natural.

Rosen’s Model of the Sciences

The theoretical biologist Robert Rosen (1991) developed a useful model for understanding how science works, portraying science as studying patterns of nature to translate into formal scientific language. Figure 1 shows Rosen’s original diagram at the bottom right, showing a science’s *formal system* as coming from *encoding* natural patterns to produce a formal language of *implication* to then *decode* again to have physical effects on nature. It offers a general model of how sciences create their systems thinking to work with nature, a cultural process for creating a language of ST for SM.

On the left in Figure 1, I suggest how the model can be generalized to compare the methods of ST for SM for other cultures as well, each creating and organized around its original language for working with nature as a method of ST for SM. Type A is for sciences like physics and other theory-centered cultures. Type B is for cultures that develop around accumulated experience and improvised practices, craft-centered cultures including professions of anthropology, archeology, architecture, and many others, the many trades, and other cultural ways of living. For generality, I include with the latter the various natural community, societal, and national scale cultures, recognized as being organized around their common roots and methods of ST for SM at their natural level of integration” (Odum 1950, p.6 8). We marvel at the ways cultures develop their separate languages for working with nature, producing fabulously diverse and reliable shared systems of thinking. That different ones tend to develop from separate roots and develop by orignal designs, naturally leaves them without ready ways to translate for others, making each its own silo established around its original paradigm.

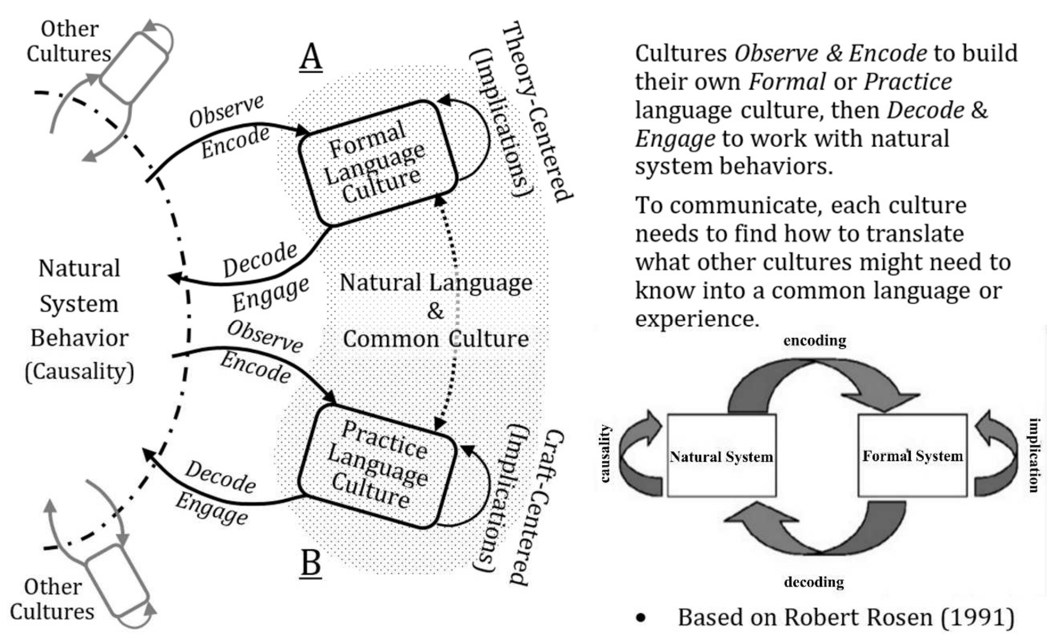

Figure 1. Model of cultures each making their separate languages for working with nature. Based on the Rosen model for cultures translating natural patterns into cultural patterns and back.

As a general model for how cultures create their knowledge the Rosen model also lets you consider how they might interact. Some remain separate while coordinating very smoothly, like how the theory-centered and craft-centered cultures of physics and engineering work smoothly together as a combined craft. That combination may be theory lead by physics for some engineering tasks or craft led as when collaborating with businesses or architects. Cultures and their languages of ST for SM do naturally develop links organically too, of course, as for integrating the many specializations that make up societies. Separate sub-cultures might insert their methods where they want to intercede or collaborate where they are needed, producing an evolutionary method of knitting society into a working whole. Even when they mingle, though, individual cultures also remarkably seem to maintain their individuality and common language for how things work, retaining their bond with their particular cultural roots wherever they go, a quite unusual topology. Subcultures and communities within a common culture would of course share some of the same roots, but like different branches of a tree, they may grow apart as they develop too.

As a model of translating natural patterns into mental ones and back into action again, the Rosen model also lets one ask new questions about what might get lost in translation. With each culture developing its separate way of collecting information and making its interpretations, each would lose different things in translation too. I think that is what we experience, and seems to be the case for the systems sciences, physics, economics, sociology, anthropology, and ecology. All study the systems of nature, but their questions, observations, methods of interpretation, and viewpoints greatly differ. Combining such diverse viewpoints on a common subject is usually thought to add perspective, but that seems to be only within a common culture. For cultures with independent roots and languages, diverse perspectives create communication barriers. As shown in Figure 1 the main option left to them is to communicate using whatever natural language they may have in common, depending on how far back they have to go to relate to their common roots.

Physics and other hard sciences, for example, seem to be limited to asking mathematically definable questions; economics to asking financial questions; sociology, anthropology, and ecology to asking their individually tailored kinds of questions too. Further separating cultures with separate ways of thinking is the tendency to explore questions for which their methods are most successful and avoid others—even if those questions are important—a pattern that steers them further away from learning from each other. This apparently natural separation of cultural paradigms of understanding seems closely related to Kuhn's (1970) conclusion that scientists tend not to adopt new paradigms in their fields, but instead cling to the paradigms they built their careers around.

Also curious is how this apparent natural barrier to communicating between cultures seems so taken for granted as to go unnoticed, each seeming quite self-satisfied with its original view. Seen as a whole, that pattern of cultures being satisfied with the originality of their views fits the roles portrayed in the ancient Buddhist parable originally describing sectarian quarrels, known as "The blind men and the elephant"(Wikipedia 2017b), of separate ways of seeing one elephant. What seems most telling is that even if any culture's view might offer quite useful insights, it also acts self-satisfied with no interest in what other cultures perceive, treating its view as quite self-sufficient, and preventing it from questioning its form of knowledge.

Action Research as a Model of ST for SM

When Lewin (1946, 1947) first developed AR, he described it as "a spiral of steps, each of which is composed of a circle of planning, action, and fact-finding about the result of the action." Lewin also intended the "fact-finding" to produce contributions to science (Stephens, Barton, & Haslett, 2009), alternating the phases of work and research so the subjects of the study could also be researchers, studying the transformations in which they took part.

Only a supportive facilitator is needed to make the AR process of work and learning self-contained (Ison, 2008; Reason & Bradbury, 2006) as participants turn their attention back and forth between the phases of work, research, and planning. Because individuals come with different worldviews and kinds of awareness, guiding them to work together becomes the art of the practice. A productive group effort, for example, needs to work for both detail-oriented and concept-oriented people, and also for people who Heron and Reason (2016) called *Apollonian* (goal driven) and *Dionysian* (spontaneous and reflective). These are among the many kinds of differing natural intelligences that people bring along with their differing professional, social and cultural ways of seeing and working with the world. AR is now a broad field with many variations, balancing the roles of action and research in different ways (Reason & Bradbury, 2006; Stringer, 2008). Lewin's (1958) *systems model* for AR is shown in Figure 2. Figure 3 then shows a somewhat condensed *process model* for much the same functions. To compare them the shaded middle stage of the systems model in Figure 2 roughly corresponds to the shaded middle three stages of the process model in Figure 3.

These models help explain the complex teamwork for such varied adaptive design practices as for business management, architectural design, product development, government planning, and environmental negotiation. In Figure 3 the circular process of Figure 2 is translated into steps from start to end alternate between review and action, as accumulative stages of ST for SM. The periods of work are symbolically shown as straight lines as if pushing on a course straight ahead toward an organizational or budgetary limit. The work might include various research and exploration tasks for presentation at whole process reviews. The reviews are shown as large circles to suggest stepping into a circle to look at things from all sides. In practice, the end of a review is also a natural time for group relaxation and personal sharing before releasing the team for the next phase of work. What makes this method so creative for complex teamwork seems fairly universal. It allows team members to first work on their own and then come together to both inspire each other and coordinate for their common purpose.

In Figure 3, the names of the work stages (SM.0 to SM.5) relate to their functions, starting from *seed* and *concept* that first initiate and then refine the starting project direction. Those are followed by the work to *organize* a plan for expanding on the concept, followed by the work to *process* and *refine* that work. That leads to the final packaging for *delivery* of the product. This way of naming work stages according to the kind of work is also generally how architects name the design phases and deliverables for design work. What brings a team together and guides the process to the end is usually a stakeholder's vision. For architects, the start may be a napkin sketch at a dinner meeting with a client, an iconic image to cling to as work begins, and to serve as a constant reminder of the purpose as work continues. In other fields, that starting seed might be a pitch made by an entrepreneur for a new business plan, by a producer for a new theater production, by a UN organization promoting a new multistakeholder partnership, or by educators proposing new curricula.

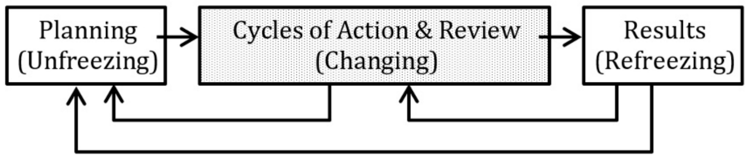

Figure 2. A systems model for the operation of AR (Lewin 1958). The management of AR with higher and lower nested levels of work and review; source Wikipedia (2017c)

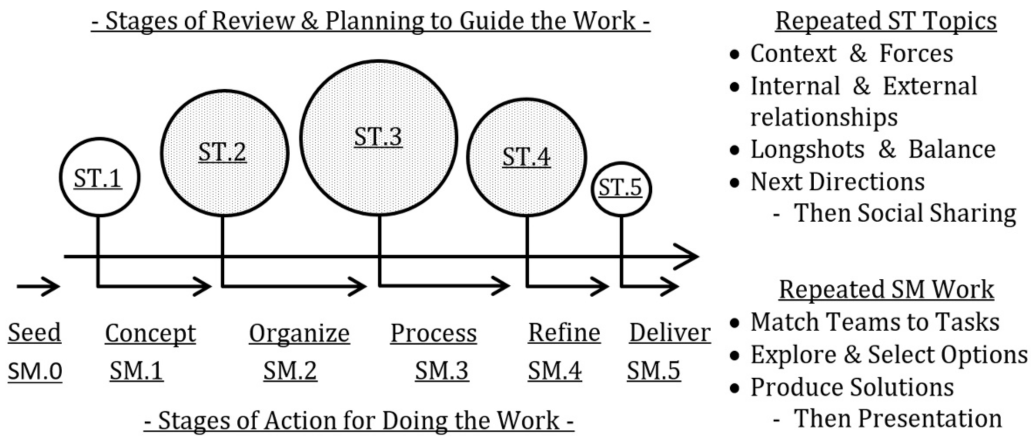

Figure 3. A process model for AR as an adaptive ST for SM sequence. Showing the accumulation of sequential stages of development from inception to completion.

Referring to Figure 3, the SM stages of action for the work of AR, begin with the *seed* (SM.0) idea or event that initiates the assembly of resources for the project. The initial study and review (ST.1) is a search for what is both wonderful and practical about the seed, and depending on the result leads to the first stage of work (SM.1) for carefully validating the *concept*. Validating the concept is often the most important work of the project, and should include a) exploring the whole context to identify the issues the project needs to work with, and b) testing initial models for achieving the true purpose within all its limits. If the review (ST.2) settles on a plan for going ahead, the next step of the work is to *organize* (SM.2) a framework of design elements and strategy for the next review (ST.3), followed by the *process* (SM.3) of extending and filling in the framework. After the next review (ST.4) the next work stage (SM.4) is to *refine* the work done for a final review (ST.5) and then the final work stage (SM.5) to *deliver* the results. It is an accumulative process of adaptive development with a natural crescendo of activity in the middle. The sequence can vary considerably depending on the field of work, the team and the project, and using the AR model's great versatility.

The main focus of the reviews is on understanding what has been learned in each stage of work to give new direction for the future vision of the project, a series of creative mid-course corrections. A brief list of ST topics to raise at AR reviews is at the right in Figure 3. That includes studying the *context* and its causal *forces* which the work needs to respond to at each stage. One also needs to consider the work's *internal* and *external relationships* that matter, the special risk and opportunity *longshots* that are possible, and the overall *balance* of all project financial and environmental budgets. Reviews typically finish with setting *next directions* and a *social sharing* at the end. Finally, the figure shows some repeated SM tasks for each phase of work: to match teams and tasks, explore and select options, produce solutions, and lastly, presentation.

Each actual project develops its own set of alternating work and review practices suited to the methods, customs, and choices of the organizers. Other core social science methods can also be integrated with AR practices. Those include soft systems methodology (SSM; Checkland, 1999), learning organization (Senge, 2006), SCRUM software development practice (Schwaber, 1997) as well as the diverse other AR methods in the literature. Alexander et al.'s (1977) and Alexander's (1979) generalized PL method of architectural design is adaptable to any field as a versatile method for focusing the holistic purposes of an ST for SM process, as further discussed below.

For AR as for other collaboration processes, what seems most important is what the participants can individually contribute, a potential that depends on how a team is brought together to present its work to each other and find new direction. People need a smooth way of displaying what they've been working on in private so the team as a whole can envision the work they need to do together. That inclusive sharing also provides social affirmation and serves to integrate the team while exposing the diverse ways each member raises questions. The combination allows everyone to understand the new directions for the work agreed to.

ST for SM in the Systems Sciences

Stories of Emerging Systems Sciences

A surprisingly simple way to display the emergence of new cultures of ST for SM is to trace the frequency of use of terms associated with their language, as by graphing them with Google Ngrams (G. N.) as shown in Figures 4 & 5. Google built a database of terms found when scanning the books of several leading libraries. Each curve in the figures traces the history of the use of that term in Google's record. The frequency of its terms provides a dynamic record at least partly reflecting the culture's growth and activity. For example, Figures 4 & 5 show histories from 1930 to 2008 for terms associated with systems sciences. Each curve seems associated with an emerging paradigm of ST and corresponding practice of SM. Some terms for more recently emerging paradigms of systems science cultures such as robotics, neural networks, artificial intelligence, social networks, and high technology seemed too short to be meaningful or outside the present scope.

With interpretation, these traces seeming to show emerging paradigms of thought in the sciences tell stories about the journey of the associated cultures. For example, Figure 4 shows a dramatic difference between the publication record for operations research (OR) and AR. Both first appeared in the early 1940s but then developed quite differently. What jumps out is the meteoric rise of OR in the 1950s followed by a sudden and continuing decline toward stability. That is quite different from the long and fairly steady continuing growth of references to AR over the same period. That difference is interesting in itself, but it also suggests there is a larger story to tell that would take probing other sources of data to piece together. Reading history from single data curves is difficult in any case, but especially for reading Ngrams. It is not clear what behaviors Ngrams trace beyond recurrent phrases, so they always need to be interpreted contextually. Different groups might well use the same terms with different meanings, for example, like terms popular in science and also popular in fiction perhaps. So we need to first treat the shapes of the curves as cartoon figures, reflecting the organic behavior of some unknown intersection of communities, leaving much to the imagination and needing other data sources to fill out any interpretation.

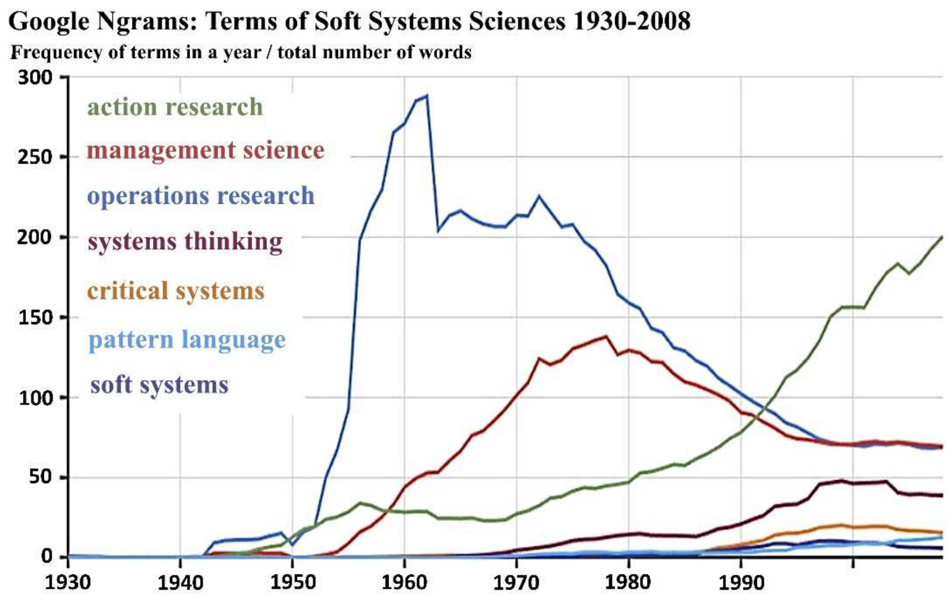

Figure 4. The frequency of use for selected terms naming paradigms for soft systems sciences. Source, Google Ngrams (2017).

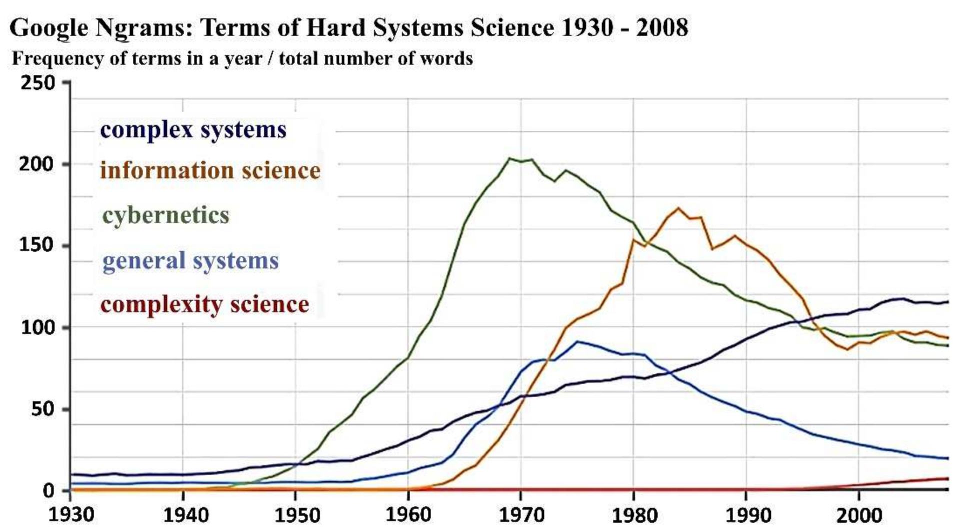

Figure 5. The frequency of use for selected terms naming paradigms of hard systems science. Source, Google Ngrams (2017).

I was quite surprised by both the OR and AR curves and unable to guess what was behind either at first. After some research, it appears the unusual rise and fall of OR was a result of what we now call *irrational exuberance*. Great excitement apparently developed around using mathematical models for business management (Simon & Newell, 1958) that then met disappointment. It seems logical that such a fascination would have stimulated great interest—and also logical that it would quickly run into problems. I did not find the exact cause of the sharp drop, but critics did soon begin to point out the obvious problems with blindly using equations for business and the critical need for management to study work environments as a whole (Ackoff, 1979).

A better understanding of the long growth of AR came from doing a few Google Scholar searches for various individual years and finding a split in the cultures using the term. For both the early and recent publications on AR, the top search pages related to practical uses in education. Most articles seemed to be for teachers using AR to extend their teaching skills and to engage students in the learning experience (Stringer, 2008). References to AR in social science research that I knew of from connecting article references were hard to find on Google, seemingly hidden by Google's bias toward returning highly ranked pages.

Some of the terms for soft systems science I included in Figure 4 could mean different things to different people. The term *systems thinking* itself might be used either in the hard or soft systems sciences or popular literature. I put it with the terms for soft systems in Figure 4 because the shape resembles two others there, the curves for *critical systems* and *soft systems*. All three have a plateau in years shortly before and after 2000. That observed coupling between the three shapes suggests some connection between the cultures behind them. None of the curves for the hard sciences (Figure 5) seem to have that shape. Though several groups might use the term *general systems*, I included it in the list of terms for hard systems sciences because the curve has a shape similar to others there.

The earliest modern reference to the term "systems thinking" was at the start of its Google Ngram in 1937 (G. N.). After that use, there was a small flurry of uses in the 1940s and then the great wave of popular use that began in 1958. The earliest specific citations I could find were both in the field of education, in Brown (1953) and Smith (1957). What triggered its great popular use in 1958 is unclear, but it might tell an interesting story. It may have been picked up as a delayed reaction to Von Bertalanffy's and Rapoport's (1956) and Boulding's (1956) revolutionary books on general systems theory (GST) as those difficult ideas rapidly became popular.

The most common general shape in this collection of curves is interesting as well. Eight of the twelve curves show an initial rise followed by a decline to a stable level. That may reflect the initial excitement of exploring each new field. It seems logical that the excitement would fade as a field settles into its permanent place. Just one of those, *general systems*, may be slowly fading toward zero as if the culture behind it was unable to mature and find its lasting place. I have studied the history of GST for years, originally being caught up in the excitement of the field myself. Perhaps the lasting problem for GST was being open to so many experimental approaches that the term gradually lost its practical meaning. The origin of GST is still of interest, having been central to the early branching of both the hard and soft systems sciences.

Out of the 12 curves, four did not fit that most common shape. As of 2008, three of those four were still in their period of initial rise, exhibiting something like exponential growth: the terms *action research, pattern language* (Figure 4), and *complexity science* (Figure 5). The large-scale and continuing growth of AR seems important, and from familiarity with the fields, the fact that both the AR and PL methods spread partly by crossing disciplinary boundaries and spread to diverse fields. The one other exception to the most common shape is the curve for *complex systems* (Figure 5). That is a term used by all the systems sciences, also found in public discussion, and found going back to the early 1800s. I think that means its recent rise may be as much a continuation of its growing use in common language as reflecting a paradigm of complexity science borrowed from common language.

Hard Systems Sciences

The hard sciences have had a long history of remarkable economic success, producing useful technology to control nature. The new hard systems sciences that emerged in the 1940s and 50s provided new abstract theories for information, communication, and system control while also seeding variations on GST throughout the sciences. It also drew attention to the unsolved problems that hard systems sciences still struggle with, understanding the apparently self-organizing and self-animating systems of nature like organisms, cultures, ecologies, economies, and the weather. Such individually developing forms of complex organization notably display individual emergent properties of their own that we still only seem to explain the way Aristotle did in his Metaphysics, as quoted by McKenon (1947), saying "the whole is something besides the parts" (Book H, 1045:8-10). Conceptual diagrams to illustrate the style of ST in the hard sciences are shown in Figure 6.

The new scientific systems information and control theory produced tremendous economic value as the hard sciences did before, resulting in products like business computers, information technology, sophisticated automation, and new tools for medicine and scientific research. The new technology also unleashed societal creativity, spreading great artistic, cultural, and economic innovation around the world. That explosion of new wealth and innovation also produced large-scale improvement in human welfare as well. Sadly, it also led to growing impacts causing new kinds and scales of poverty, war, and environmental and cultural disruption, as evidence of some great loss in translation in forming our new languages of ST for SM.

A short list of milestones for the emerging hard systems sciences begins with Wiener's (1948) cybernetics (control theory), followed by Shannon & Weaver's (1949) theory of communication, and then Ashby's (1952, 1956) information theory, forming the basic building blocks of abstract systems science. A unified framework for them emerged in the 1950s called general systems theory (GST), led by the biologist Von Bertalanffy and the mathematical psychologist Rapoport (1956) and separately by the economist Boulding (1956). In the 1960s Simon's (1962) "Architecture of Complexity" and Von Bertalanffy's (1968) second book on GST, brought more formality to the rapidly expanding field. GST held great promise as a means for telling rich stories of how the complexly organized things of life actually work and a great diversity of new branches of systems science sprang from it (Henshaw 2010b).

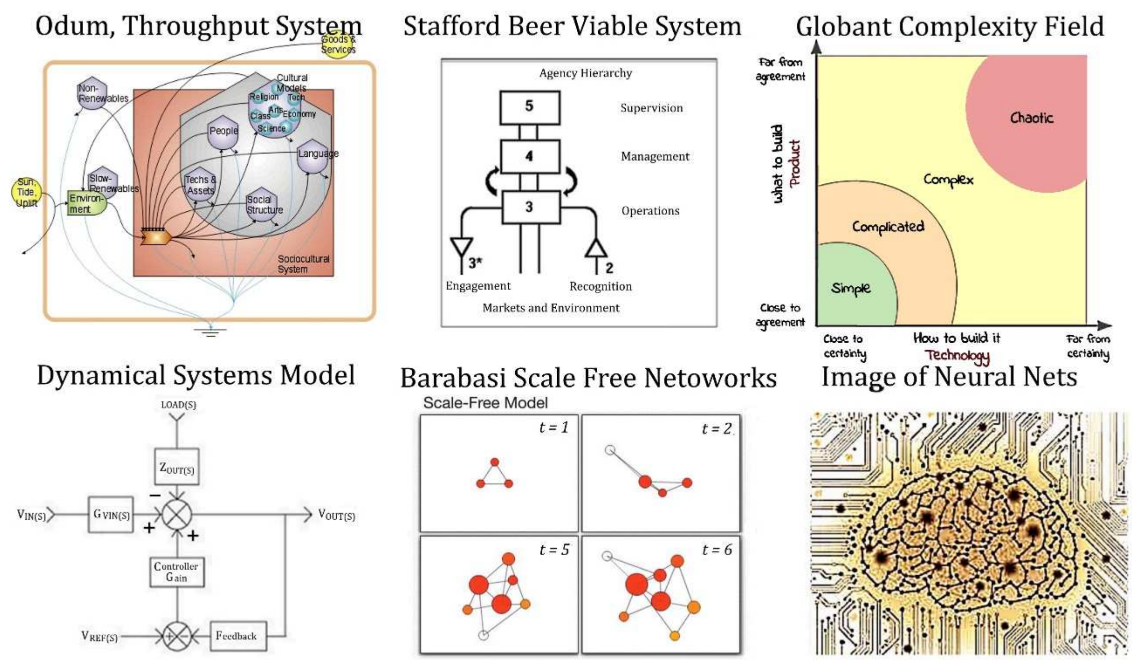

Figure 6. Conceptual diagrams to illustrate the style of ST in the hard sciences. Assorted images used for interpreting the patterns of theoretical systems.

A few of the milestones for more recent hard systems sciences can start with the discovery of nonequilibrium thermodynamics by Nicolis and Prigogine (1977) for the deterministic study of self-organizing systems. Georgescu-Roegen (1971) then extended the entropy principle to the study of complex economic systems. Many people think the turning point for the study of complex deterministic systems was the use of high-speed computer modeling that produced chaos theory (Feigenbaum, Kadanoff, & Shenker, 1982) and the theory of fractals (Mandelbrot & Pignoni, 1983). The foundations for computer simulation of life was laid by the study of cellular automata (Wolfram, 1984), and the development of nonlinear neural networks (Grossberg, 1988) laid the foundations for learning machines. Applications of these new fields of systems mathematics included the invention of neural networks (Cochocki & Unbehauen, 1993), artificial life (Langton, 1989), and artificial intelligence (Russell & Norvig, 1995). These advancements in emulating life systems with algorithms for autonomous agents became the foundation for today's learning machines and robotics. Together those fields seemed to open the door to explaining nature within a mathematical phase space of far-from-equilibrium equations (Kauffman, 1993). Holland (1992) and Gell-Mann (1994) then unified large parts of the field with the development of complex adaptive systems (CAS).

Two difficulties remained, however: (a) discovering how the organization and emergent properties of natural systems developed and (b) emulating the flowing organizational change displayed by complex natural systems. This failure to progress in emulating nature presented a sufficiently fundamental problem to bring into question the whole way of defining the question; I think perhaps even to asking whether nature works as we attempt to model it, as following our rules for information. David Pines (2014), one of the founders of the Santa Fe Institute of Complexity Science, put the problem the impasse causes this way:

> Although we know the simple equations that govern our immediate world, we find that these formulas are almost useless in telling us about the emergent behavior we encounter, whether we are working on a problem at the frontiers of science or seeking to understand and change familial or societal behavior.

The emergent properties of natural systems evidently came from the organization of their parts, as in the profound difference between separate players and a team. It appears to be the organization of whole systems that does it, but the challenge of defining how or why still seems beyond reach using the methods widely tried so far. Consequently, some new way of learning about how natural complex systems develop their unique properties seems needed.

Life Systems Sciences

One place to look for other approaches to understanding complex systems is in the older fields of systems study such as economics, anthropology, and ecology. Some of their methods were developed well before physics began to emulate self-organizing systems with the axiomatic rules of information and control theory. The life systems sciences, in contrast, take the organization of nature simply as a fact and carefully record its emergent properties, much the way physics also developed as a direct study of physical properties rather than as pure theory before the 20th century. Conceptual diagrams to illustrate the style of ST in the soft systems sciences are shown in Figure 7. Another foundation of the life systems sciences is the use of simplified models as explanatory principles and exemplars of how whole systems behave. A classic example is Jevons's (1885) 130-year-old observation of a simple but counterintuitive emergent behavior of economies. He noticed that improving the efficiency of technology to reduce resource uses per task tended to increase the number of uses enough to increase rather than decrease the total consumption of the resource. Efficiency makes technologies more profitable to use and would expand their use along with the economy as a whole (Henshaw, P., King, & Zarnikau, 2011; Polimeni, Mayumi, Giampietro, & Alcott, 2008).

Simple models of system behavior, like Jevons' principle, often become explanatory principles and building blocks of the life sciences. The anthropologist Margaret Mead (Mead, Sieben, & Straub, 1943), following the guidance of Boaz, was able to document that human cultures are socially not biologically inherited systems of information, for example. Ecology also relies on the recognition of simple explanatory models, like food chains, to help explain complex environmental systems (Odum, 1983). This approach to defining systems shows clearly in the way Odum (1950, p.6 8) defined ecology: as the study of large entities (ecosystems) at the "natural level of integration" (p.6 8). Both Mead et al. and Odum also used those simple models to associate their language terms with the subjects they studied, cultures and ecology, helping them coordinate their mental categories with observable systems of organization in nature. That allows the direct study of natural systems and avoids reducing them to abstractions. Another example is the popular Panarchy model of evolution developed by Gunderson and Holling (2001), which associates adaptive renewal in ecosystems with the seasonal cycles of ecological decay and adaptive rebirth. Panarchy also approximates the periodic succession of economic technologies, as when recessions trigger business retooling as the economy reorganizes for the next growth cycle.

Social Systems Sciences

Baskerville and Meyers (2004) suggest that the intellectual foundations of AR were laid by the intellectual premises of Pierce, James, Dewey, and Mead in the 1930s. They cite Dewey's logic of controlled inquiry, in which rational thought is interspersed with action and Mead's tenet that human conceptualization is also a social reflection. The careful experiments of Lewin (1947) were the first to formalize AR. Similar experiments were also in process at the Tavistock Institute at the same time, combining the treatment of battlefield trauma with experimental changes in the therapeutic environment, making the researchers part of their experiments (Trist, 1976). AR practice also developed very early in education (Corey, 1954).

Interest in OR developed at about the same time as AR (Figure 4) but focused on the use of mathematical models for business (Simon & Newell, 1958). It also attracted some of the leading thinkers who would later break away from OR (Churchman, Ackoff, & Arnoff 1957). The early influence of GST on the social sciences seems evident in the visionary thinking of McGregor (1960). McGregor proposed a rearrangement of the traditional business organization, incorporating the new social principles found in Argyris's (1957) Personality and Organization and Maslow's theory of human motivation (1943, 1971). What McGregor called Theory X was the old style of business management that treated workers as naturally indolent and needing to be controlled. He based his new model, he called Theory Y, on the expectation of individual self-realization. That model is still a guiding vision for the workplace and societal attitudes today, even as global society struggles with strong opposing forces of ever-growing economic inequity, government instability and waves of social and workplace insecurity.

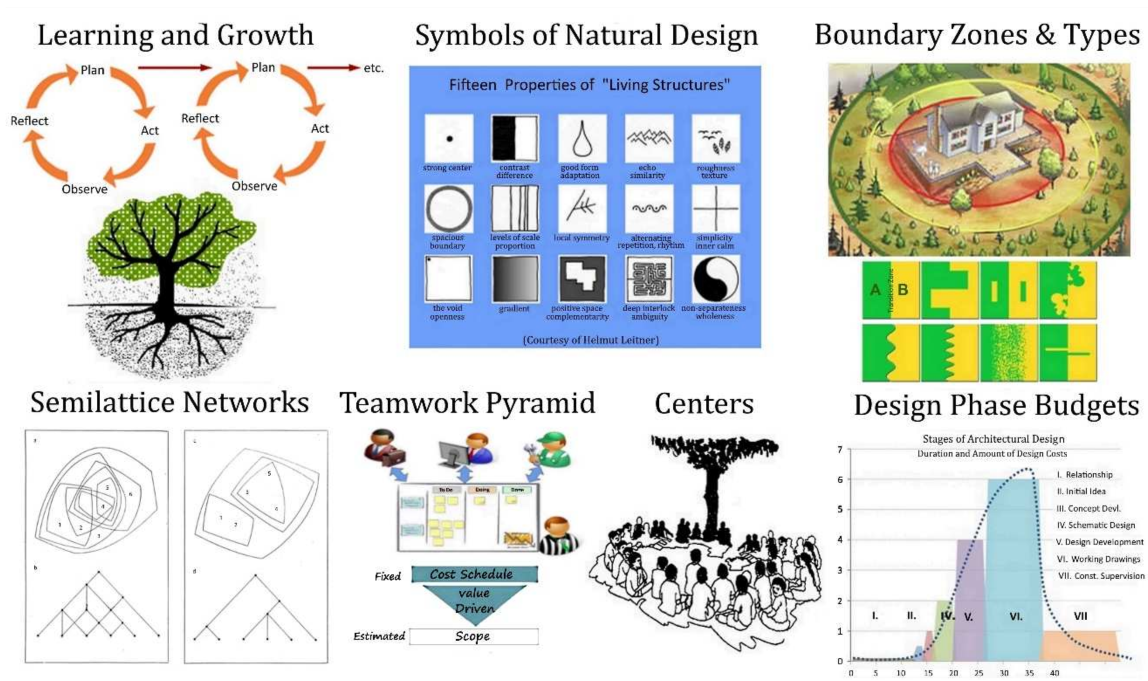

Figure 7. Conceptual diagrams to illustrate the style of ST in the soft sciences. Assorted images used for interpreting patterns of naturally occurring systems.

Argyris (1977) added important systems principles for working with natural subjects such as double-loop learning, a discipline for both questioning one's research methods and assumed purposes. Churchman (1979) observed that social boundaries need not be dividing lines, but could be any relation of inclusion or exclusion, as one finds in concepts like personal space, niches, cultures, and neighborhoods, recognizing boundaries defined by working relationships. At the time Ackoff (1979) was writing "The future of operational research is past" breaking with OR and the overuse of equations for business and Churchman (1979) was writing "The systems approach and its enemies," demonstrated the value of critical ethical awareness.

In the 1980s and 1990s, several important innovations in systems management gained prominence. One was Checkland's (1981, 1999) soft systems methodology (SSM). SSM focuses on defining a learning method for a business fully integrating AR within its practice (Baskerville & Wood-Harper 1996). It also emphasizes the use of natural language rather than jargon and the use of multiple system models to compare their fit with reality. A second was the practice of critical systems thinking (CST) (Flood, 2010; Flood & Jackson, 1991; Midgley, 1996). CST emerged as a set of high-level standards for applied ST, with central commitments to critical awareness, the emancipation of subjects and methodological pluralism.

Both the architectural and software design fields and business management fields produced major ST for SM advances in systems learning. Alexander's PL (Alexander et al., 1977;Alexander 1979) emerged as a new kind of science for guiding the purposes and methods of design, spreading from architecture to various other fields beginning in the 1980s. Its greatest societal impact has been helping software developers focus the true purposes of their work (Rising, 1998; Tidwell, 1999). Other important innovations in organizational development were Senge's (1990, 2006; Senge et al., 1999) five dimensions of learning organization for business and the agile approach to business management and software development methods such as SCRUM (Conboy & Fitzgerald, 2004; Schwaber, 2004). Jackson's (2003) creative holism is another noted ST for SM approach that focused on advancing organizational learning. Together these and other innovations represent a true revolution in learning methods for highly productive teamwork. At the same time, the use of AR continued to spread, especially in education (Carr & Kemmis, 2003; Stringer, 2008).

Notably, PL, AR, and agile methods all seem to easily combine with others to produce hybrids used by varied professions and spread from one community to another. The ability to identify versatile design principles adaptable to the questions of other fields makes them somewhat like viral technologies with many uses, like parts of an emerging scientific method of learning systems. A simple illustration is the home and family use of agile business methods (Feiler, 2013). Feiler's simple use of agile for the home aims at creatively empowering children and their issues while enriching family communication. Like a simplified practice of AR, agile for a family regularly revisits three questions about family work and tracks progress on a kitchen bulletin board; asking (a) what is working well, (b) what might work better, and (c) what to work on next. As with all of the above system learning methods, even this simple one, the true foundation of the knowledge each represents is the active culture and practice of its creative users. Thus, absorbing some of the culture and practice that goes with them is an important part of getting them to work successfully.

Natural Systems Thinking

The previous sections surveyed the history and various broad patterns of adaptive development in nature and our use of adaptive development in ST for SM, both for quite ordinary tasks as well as formal methods of professional system learning. That review could provide contextual research for the concept development phase for some AR teamwork project, perhaps to explore new methods or applications for adaptive ST for SM. This section on natural systems thinking (NST) offers somewhat experimental models for enhancing the practices of adaptive ST for SM. If they seem too experimental, just consider them as long-shots to play with for broadening the inquiry in review and study periods of AR.

Added Focus on Reality

NST is for extending the direction of both the hard and soft systems sciences for increasingly focusing on reality, importantly by turning attention to individual natural systems rather than to general categories. That attention to the individuality of subjects brings out the individuality of the stories they tell, and the individuality of their organizational designs. Every business and culture has its individual patterns of relationships, for example, as also found in any community or project team. Thus, the focus of NST is more on observing things than explaining them and on recognizing natural systems by their own "natural level of integration" as Odum (1950) did (p. 6 8). For a theory of NST, perhaps Goethe's somewhat formal precept would be enough to start, saying: "Seek nothing beyond the phenomena, they themselves are the theory" (cited in Riegner, 1993, p. 181). My research in the 1970s accidentally started from that approach. I became fascinated by lively organizational development processes that followed a pattern of smoothly rising then falling action, often exhibiting a traceable S–curve also called a sigmoid shaped progression, as a useful proxy of the underlying organizational process.

What usually seemed clear in my observations is that energy events involved organizing the energy using system as well, its organization developing from the inside rather than driven by the pushes or pulls from outside. In a successful field study of the microclimates of homes (Henshaw. P., 1978), I closely watched how the complex designs of individual warm air convection currents developed near sunlit surfaces. From calm beginnings they first developed slowly then more rapidly, their internal designs becoming more organized and complex, to later be disrupted or separated from their energy source. After a while, I recognized that natural crescendo as associated with the organizational development of energy using systems of all kinds, which led to many other studies.

NST borrows three principles from CST: critical awareness, emancipation, and methodological pluralism. NST applies these principles primarily to the individuality of natural system subjects or developed circumstances, not just for people and human relationships. Similar to CST, critical awareness for NST involves challenging assumed interpretations and learning to approach individual subjects and circumstances from diverse points of view. For NST the principle of emancipation for individual systems and circumstances applies to their contingencies and implied interests in their internal and external patterns of relationships. A local ecology or social culture, for example, would then be treated as an individual with a right to be considered as a whole, regarding the relationships of their internal designs, external niche, and roles in the environment. For example, one might speak of an ecology's implied interests in its many species and niches, taking care to avoid attributing human cognition or intention in the contextual interests of nonhuman subjects. Finally, for NST methodological pluralism means using a variety of exploratory methods to consider natural system subjects from multiple perspectives.

For example, Midgley (2016) points out that as thinking animals we need to consider four forms of complexity, natural world, social world, subjective world, and their interactions (Table 1). Most often when we consider natural system subjects, we turn attention back and forth between social worldviews and subjective worldviews. If we then shift to a natural systems worldview many things change. For example, a business culture is then seen as an ecology, having various self-organizing parts that need to work together as a whole and serve the business's roles in the larger environment. As Pflaeging (2014) suggested, we might consider a business as having three main subcultures: a management culture, a social culture, and a productivity culture, plus their interactions, Table 1. Each of those self-organizing cultures provides different but essential operational knowledge for the business, so awareness of and care for each as a key business resource would seem important for working smoothly. Like cultures of any kind, one would expect each subculture to have a continually evolving design, life of its own and ways of interacting with the others. The main value of recognizing these business subcultures as individuals is not for making a highly complex analysis. It is to learn to notice their implied interests as wholes, and so provide a simple framework for adding to your understanding of them. It leaves quite open how to relate to them and helps one recognize more of the real working relationships and options to consider.

Table 1 NST terms for perspectives on natural complexity and structures of business culture for recognizing the relationships between three different natural worldviews and intersecting business sub-cultures to help with navigating complex relationships

Midgley (2016) Natural Forms of Complexity.	Pflaeging (2014) Natural Business Cultures
natural world	management culture
social world(s)	social culture(s)
subjective world(s)	productivity culture(s)
& interactions	& interactions

The value for NST of this intersection of complex of points of view and business structures is not the complex analysis possible, but just learning to move easily from one view to another, helping assure the right issues get explored and responded to. It also helps one develop more holistic understanding to use mental categories that better fit the natural structures. Bateson (1972) observed it is better to ground one's perceptions in actual subdivisions of the natural world rather than in stereotypical labels or abstractions created for convenience (p. 64). One often finds useful patterns of natural design like these in unexpected places, such as hidden in plain sight. A related research paper (Henshaw, J., 2015) includes discussion of various others.

The way people first notice unfamiliar cultures is often as an intrusion and apparent demand for unfamiliar responses. What I find begins to open the door to understanding them is to recognize that the first job of every culture is to make a good home for its internal way of living, establishing its niche and place. That is what any ethnic, family, community, business, or other kind of culture does to establish itself. That understanding gives purpose to what first appears as an alien way of living and exposes a mixture of inside and outside perspectives from which to view it. For example, when first going into someone else's home, neighborhood or business, what we first notice is strangeness. That strangeness is an outsider's experience of what the culture does to make its world familiar. It is still hard for an outsider to know what matters, but thinking of it as someone or something's home provides a framework for starting to put together the pieces.

To distinguish between subjective world and natural world meanings of terms, NST refers to them as exhibiting, respectively, either a conceptual intent (referring to mentally defined constructs) or a practical intent (referring to things defined by nature). It is actually a simple distinction. Examples of practical intent are using apple to refer to apples, storm to refer to storms, or sorrow to sorrows, each term used to directly refer to something defined by nature as opposed to defined conceptually. In normal conversation, we make the switch from one to the other intent all the time, as when we go from thinking about doing something to doing it. That is a change in intent from conceptual to practical, from ST to SM. For example, when asking people to help clean up after a family dinner, we are speaking conceptually, but people then normally shift to thinking practically and turn their attention to finding what remains to be done, switching from thinking about helping out to doing an environmental search. For some people, the two ways of thinking may be hard to separate, but our bodies seem to do it rather casually, in any case, working as physical systems that alternately pay attention to thinking about the world and then to acting on it.

The natural hesitations people often have when switching from planning to doing things also shows how important the difference between conceptual and practical intent is. For example, a novice will be a bit frightened by the prospect of going from conceptual to actual dancing, or from conceptual to actual swimming. When you only know how to do things conceptually, there is often a natural emotional barrier to doing them practically, knowing how to start technically but not having the comfortable intuition that would come with experience. When making investment decisions or other momentous choices, it is the same. What Keynes (1935) called "animal spirits" as a "spontaneous urge to action" (p. 161, Ch12/VII) is an emotional hurdle needed for people to commit to seeing through choices for taking naturally unpredictable risks with uncertain outcomes. The effect may reverse too, however, for subjects you have no practical understanding of at all one's conceptual thinking can seem like a guarantee of success for plans sure to fail. One might also ask where objective intent would fit, often imagined as both practical and conceptual. One often makes assumptions while trying to be objective, as when assigning one's cultural categories to nature. That says some objectivity is subjective and adds to the challenge of being open-minded.

This way of developing holistic views from multiple perspectives came from years of varied observation and rich conversation on the interesting problems of life, combining cultural, literary, natural science, social science, and architectural design perspectives. What then first bore fruit was the field study of building microclimates and the general model for studying complex system transformations it led to (Henshaw, P., 1979). Years of research and papers on natural learning systems followed (Henshaw, P., 1985, 2008, 2010; Henshaw, J., 2015). There are many other useful references for exploring individual patterns of natural design. Alexander's "A city is not a tree" (1965) describes his observation that living system semi-lattice networks foster opportunistic not deterministic connections (pp. 58-62). A Pattern Language (Alexander et al., 1977) and The Timeless Way of Building (Alexander, 1979), describe design patterns that are receptive to life. Jane Jacobs (2000) wrote remarkably accessible books on the organization and evolution of the life of cities and economies, such as The Nature of Economies. Among other good resources are Bateson's (1972) "Steps to an Ecology of Mind," Goodwin's (1994) book on patterns in evolution, Meadows' insightful principles for "dancing with systems" (Wahl, 2017), and Benyus' (2002) insights into biomimicry.

The Heart of Pattern Language

Alexander's PL (Alexander et al., 1977; Alexander, 1979) is a general method for focusing holistic purposes of design using a practical structure aimed at reviving ancient architectural practices for creating structures serving life. For example, having shops by a bus or train stop, park benches in nice locations, or public squares in the heart of a city are all unusually satisfying attractors for creative and enriching life activity. Not only architecture but any other kind of design can also focus on creating satisfying patterns of organization with emergent qualities receptive to life. Small examples include perfect objects like keys, a teacup, a vase, maps that are easy to read, or a small pocket mirror or pocket knife. Larger examples are the combination of wheels and axels to make mobile vehicles or democracies organized around separate but equal branches of government. Each design is a fairly simple structure with powerful emergent qualities that transform a complex problem with remarkably satisfying results. PL is a practice of finding and describing such innovations in any field.

In Alexander's language, those kinds of special combinations spread living quality in their surroundings at the same time as they solve particular problems. These kinds of expert solutions are called design patterns, descriptions of how things work that identify the deep logic of very successful designs that might also be applied in similar circumstances wherever they occur. Their description needs to be a bit more complete than a design principle and more general than detailed instructions. Recording them carefully enough so any reasonably skilled person in the field could succeed in using them makes them suitable for presenting in pattern discussion forums and adding them to resource collections.

Some design patterns are found by mining great past solutions to identify their essential working contexts and features. Others come from recognizing a context in which there are unbalanced forces that a well-made structure would offer a satisfying way to balance. For example, an office might have unbalanced social relationships making everyone unhappy, a problem that is only recognized when people start calling it "lazy interns." With some observation and discussion, someone might identify a set of particular unbalanced forces as the origin of the annoyance and wasted potential. In this case, a good way to relieve the problem might come from giving the interns the right kind of increased responsibility and competition for rewards. In another case, it might be letting them specialize and work together as a team.

Both ways of giving the role of interns greater value in the business solves the same unbalanced set of forces, making each a variation on the same design pattern.

Pattern Name	1. Rich Context	
Authors, ID, Date	2. Situation to Resolve	(Problem)
Image	3. Forces to Bring Into Balance	(Insight)
	4. Fitting Organizational Structure	(Solution)
	5. Functional and Living Qualities	(Benefits)
References	6. Details & Outcomes	(Narrative)
Examples	7. Possible Liabilities	

Figure 8. Terms defining the structure of knowledge needed for developing or recording pattern language design patterns. An explicit framework for making the ancient principles of architectural design available to any discipline.

Figure 8 shows an adapted outline of Alexander's (1979) process of holistic design, a list of headings also used for recording written descriptions as design patterns. The design ideal expressed by Alexander is similar to the one commonly attributed to Vitruvius, that good architecture is a mixture of "commodity, firmness, and delight." Alexander's approach seeks the same perfection while being more explicit about how to do it, making it more transferable and useful to different fields. Using it to focus the design purposes of an AR project, one would simply turn the list of issues in Figure 8 into questions to ask during review periods (Figure 3). A practical way to introduce it to a team would be to circulate Figure 8 with a paragraph of text in project literature on how to use it, then have a limited discussion, keeping it quite simple at first. If used well, it would help streamline the identification of the forces that matter, clarify the problem to be solved, and make it easier to find fitting structures for solving it and bring living quality to the whole.

Collections of design patterns can be in the form of text documents or archived on a specialized design pattern wiki (Köppe, Inventado, Scupelli, & van Heesch, 2016). Various groups adopt formats of other design. The format in Figure 8 is similar to the most common ones but with a focus on the middle three items (3–5), what I call the "heart of PL." That starts with step 3, recognizing what forces are out of balance as the needed insight, then step 4) finding a fitting organizational structure for resolving them, and step 5) drawing out the emergent properties of functional and living qualities as benefits. As mentioned before, it pays to learn something about the practices and cultures from which expert practices like PL come. The key to real success is often the first step: the initial rich observation of the context. One technique for clearing the mind of preconceptions when searching a context for how to work with its natural parts (Henshaw, J., 2013) can help get things started. Links to many writings on PL and collections of design patterns to study are available from the Hillside Group (1993–2017) among others. A wonderful source for high-quality design patterns for civil society is Schuler (2008).

Reading Life Stories

Developing story arcs to help animate life stories of growth and transformation is another way to gain perspective on complex change, a narrative kind of ST for SM. It would just take some storytelling imagination and perhaps some study of natural paths of development (Henshaw, P., 1979, 1985; Henshaw, J., 2015). The modern idea of story arcs comes from Campbell's (1968) recognition of the hero's journey as a universal story, with the following synopsis. A hero ventures into a region of supernatural wonder, achieves a decisive victory over fabulous forces, returning with the power to grant benefits to his fellow man. To stimulate one's storytelling imagination Table 2 offers a list of other challenges and quests that shape the arcs of life stories. Finding a story that fits a pattern of change both gives it meaning and offers a better view of it as a whole. It is also a useful kind of hypothesis for a continuity of connections that is somewhat testable. Because a story needs continuity to make sense, it can be tested with new information to see whether the story still fits or whether gaps appear that need to be filled in to restore the continuity and make sense again. That kind of thinking could take place during the review periods of an AR process, perhaps setting the next direction for the work as building on the emerging sense of the story.

Table 2. Evocative names for life story arcs to stimulate the imagination and to suggest how to build storylines around life's absorbing challenges.

Life story Arcs – Journeys of Growth and Change		
coming of age arc	the hero's journey	growth arc
transformation arc	the home builder	partnership arc
true discovery arc	calm before the storm	deadly sins arc
taming the wild arc	plans interrupted	integrity arc
missing players arc	navigator's tale	branching horizons arc
quagmires arc	guardian of the flame	indomitable will
novice's arc	Tom Sawyer	tragedy of the commons

Finding the right story in business is a classic CEO challenge. One example comes from a business school case study (Aaker & Schifrin, 2015):

> When Mindy Grossman became CEO of HSN in 2006, she had three major challenges: create a new story for a 30-year old company that had stagnated, cultivate a growth story to change the course of the brand, and tell new stories about the products it sold.

To do that she might develop a variation on the story arc of "The Little Engine That Could," by describing how the business could pull its strengths together and get some help to take control of its challenge. The story then becomes something that draws a meaningful path into the future, stimulating interest and imagination for finding how to get there. I previously discussed ways to learn from Ngram data curves for emerging paradigms of systems science, several of which seemed to show story arcs of early exuberance before settling down. Fitting a story to the facts is a great test of the imagination and ability to find new facts to test it. It helps get people past the common problem expressed in the widely Quoted Talmudic saying "We do not see things as they are. We see things as we are." That is often a big challenge for both individuals and organizations.

A person's life story begins with the circumstances of their birth and proceeds with their childhood and youth, leading to adulthood where they discover the series of roles and relationships in the world that become their legacy. The arc of the story is both its central themes and the curves we can trace of the rising and falling action and progress of its development. Nonfiction arcs are much the same as fictional ones but based on actual events and the real developments that tie the story together. A drawing of the arc might both trace the action and the progress of the story as two different indicators. One might also trace qualitative indicators like tension or comfort and economic indicators like resource supply. Each curve just needs to trace the same continuous indicator for the same system from beginning to end. A business might look for its story to be told with indicators such as sustainability, revenue, person-hours, and cash flow, for example. What holds either a good story or a life together is the continuity of the accumulating developments, how each step builds on the past and is then a foundation for the next. Steps that do not connect, like out-of-place scenes in a play, are strong evidence that something is missing from the story, and so serve as clues that help with searching for what will fit to restore the continuity.

A narrative arc with rising and falling action and accumulative progress is easy to base on most common experiences, like getting up in the morning. Like almost any story, getting up in the morning starts slowly at first, building up to a flurry of activity to then finish with small steps in the end (the action). The progress of those steps is accumulative, aimed at adding up to real accomplishment in the end, a completion that is satisfying (the development). If the subject is something very familiar like getting up in the morning, one can easily keep track of any a particular morning's steps, and tell if there is extra time or a need to hurry. Such informal ways of reading story arcs also transfer to reading the arcs for bigger projects; only you need to do more work in developing the view of the whole story. I show some suggestions of how to approach that in Figure 9, beginning from the universal arc of just rising and falling action. However complex a development process is, it will still involve stepwise improvisation that begins and ends with small steps, with some natural crescendo of action in the middle. The curves in Figure 9 show that peak of action in the middle in two ways, as the peak of the activity rate in the middle, and as the steepest point of the accumulative development curve also in the middle. Activity and development are not always aligned like that, as in some cases the greatest activity might well occur either before or after the most development is occurring.

At the top of Figure 9 are the development periods of narrative arcs for tracing a story from three perspectives. The first, Awaken, is a story structure of smooth rising and falling action, smoothly rising toward a climax and falling again. The second, Spark, is for physical system development, taking off after a spark initiates a feedback process for building up the system. The feedback process organizes the system to work as a whole, but also pushes the development to its limits, causing a pivot to a feedforward process that finishes the development by adapting the system for its future and achieve stability. The third narrative arc, Germ, is for the starting periods of a new life, beginning with growth for individuation that once complete pivots to maturation, developing toward achieving independent life at the end at a peak of vitality. Below the three narrative arcs are two curves that trace the rise and fall of the Activity Rate and the Development progress toward a stable climax.

1	Awaken	Rising Action	Climax	Falling Action	Resolution
2	Spark	Pos-Feedback		Pos-FeedForward	Resilience
3	Germ	Individuation		Maturation	Life

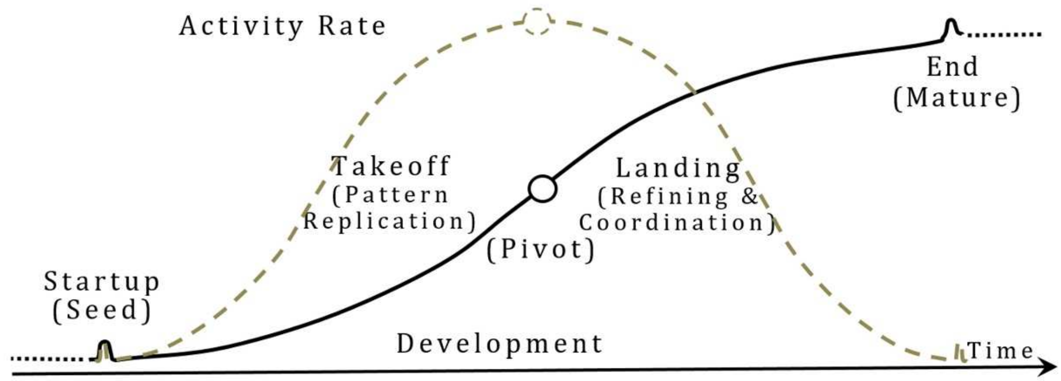

Figure 9. Milestones of simple life story arcs and their chains of development. Three narrative arcs: 1) Awaken (story action), 2) (Spark) physical process, 3) (Germ) emerging life; for story arc curves below showing Activity Rate and Development; from startup to takeoff, pivot, landing, and end.

What may take a little time to understand is the difference between reading an activity rate curve and a development curve. The activity rate is information about the developing system from an external point of view, like a person's height or weight. The development curve as a story of a system's accumulating internal organization and relationships. An activity rate is just information and has no real need for continuity or smaller scale events of startup, pivot, and end. The building of an actual building needs them though, like a groundbreaking to get the work started and to finish with giving keys to the new owner. Any team project in an office needs these connecting events too, to have the spark of from someone's suggestion take hold and start the process of building up the work, and when the goal is clear pivot toward completion. Then the work builds down again to finishing details toward the end, followed by release of the product and the team and the filing of records. These seemingly small connecting events that mark each new direction of change are quite instrumental in building successful adaptive designs and well worth examining.

It is a universal story that any developmental emergence or transformation retells, of steps of change building one on another with their real fit discovered only with each step, like stepping stones. A hand-drawn curve and list of milestones to represent the story might first seem uneventful. We know from experience, though, that any actual life story is a series of absorbing challenges. Those challenges also tend to come with small but memorable startup and concluding events. Some are more obvious, as for a business startup, the handshake that started it or the time when it breaks even. A graduation ceremony is often highly anticipated but finding the vague plans for the future becoming real the week after might be what sets someone free to make big choices. Turning points in transformations can be hard to pick out too, such as momentous change marked only by a gradual shift in direction as when a development process pivots from takeoff to landing. The point of maturity when a new system is ready to stand on its own could be hard to identify, remaining unclear until some test arises.

Start up	Takeoff		Pivot	Landing	Finish
(growth)	Emergence	Differentiation	Integration	Refinement	Maturity
(projects)	Concept	Organize	Process	Refine	Deliver
(building)	Groundwork	Structures	Infill	Finishes	Occupancy
(learning)	Challenge	Exploration	Discovery	Mastery	Integration
(design)	Images	Patterns	Execution	Details	Delivery

Figure 10. Model story arcs for common processes, with terms for their development processes and ends. Showing suggested terms for the beginning and end of takeoff and landing periods and their finish state. The startup, pivot, and end events on the top line apply to each.

One never gets the whole story, but just starting the work of giving meaning to a story arc with a series of milestones does organize what you know and builds a framework for adding other information as you come across it. An overall framework for change helps a lot with developing useful stories. If there seem to be big gaps one can do what a writer does, look for where the absorbing challenges are likely to appear in making the needed connections from one milestone to the next. To develop a useful story arc for a particular project, just start from one's own or another's experience or do a search for a good model to start from, such as looking over those listed in Table 2, or the five narrative models in Figure 10. To read those five models first think of familiar corresponding examples of growth, projects, building, learning, or design, and then their development stages from beginning to end. Try to use the suggested names for the development periods for starting and ending each takeoff and landing period. They are intended to describe the corresponding natural processes. Any way of characterizing the development stages could be OK, though. What matters is that the connecting parts of the story relate to the connecting parts of the actual process.

To bring a conceptual story arc to life add some information about the actual events and developments of its story, and draw a shape of the action from start to end. For example, you might diagram a story of a recent semester or an important familiar project, listing the challenges on a timeline and drawing the overall shape of the takeoff and landing. To make sense of it, one might need to discover that some of the challenges corresponded to periods of coasting and then pushing to catch up, trying to stay on track. That might give a gentle or quite bumpy shape to the curves. New evidence might change the story or require changing the shape of the curves or spacing of milestones. Inserting missing steps could force a general adjustment, making some transitions slower or more rapid so all the parts fit. Just as for the simpler method outlined above, the main thing a developed story arc produces is an informed view of the process as a whole, and a place to put new information as it develops.

The developed story becomes a useful narrative style of ST for SM that helps a person or a team think on their feet as the events and conditions of a project unfold. To use it to inform an

AR project one might ask how the story of the project is changing at each review. What really holds the story together and makes it useful is how it provides a model of change regulated by its need for continuity, making you to look for how the developments all connect. In that way, it is also a practical kind of scientific hypothesis that one can push around and find ways to test. Improving on it only makes it a somewhat better hypothesis, of course, but the understanding of the whole process it provides is likely to prompt much better questions, make one more alert to what is developing and what is not, resulting in higher confidence methods of making confirmations as well.

Discussion

This review of ST for SM seems both a bit lengthy and also abbreviated, hopefully striking the right balance. I have approached it from several directions as groundwork for a general approach to finding better natural models for working with change, illustrated with simple examples and a few advanced subjects. I have aimed to use an exploratory method and present a holistic view while also trying to raise good questions for use in applications. Thus, the paper already contains as much discussion as seems needed, and a reader might just skim through the varied sections to refresh his or her view of how it all came together. Various subjects also needed to be treated somewhat lightly or not explored too. For example, I did not discuss systematic methods for making things and the thinking to go with them. These gaps might be subjects for another time, or they could be explored as independent studies.

The following notes and hypotheses recall some of the themes of ST for SM:

1. Adaptive design and step-wise development are part of most kinds of human work and learning and are observed widely in nature.
2. ST for either formal or informal adaptive design involves turning one's attention back and forth between conceptual and practical thinking.
3. The general model of AR describes a recurrent pattern found in seemingly all practices of adaptive design, informal and formal, making a wide variety of learning examples available.
4. The general model of AR also fits the pattern of the Rosen model for how sciences and cultures develop their languages for working with nature.
5. How cultures each tend to independently develop their ways of working with nature, forming their unique style of ST for SM, also makes it hard for them to communicate.
6. The emerging paradigms of the systems sciences are shaped by exploring new methods for understanding and working with the reality of nature.
7. The great success of the hard sciences still leaves the emergence of new organization in nature unexplained, while the soft sciences focus more on approaching nature as it is.
8. Using simple models to help study complex organization in nature has been successful for the life sciences and seems versatile as a general method.

9. A practice of NST uses a variety of simple models for focusing attention more directly on individual subjects of nature rather than invented categories.

10. Learning to study cultures as establishing homes for their individual ways of living helps one understand them from both inside and out.

11. The "heart of PL" offers a versatile way to focus on the high purpose of achieving structural designs bringing living quality to organizational change.

12. The use of story arcs for growth and development offers a versatile narrative style of ST for SM to guide developmental change.

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