Systems-thinking for Systems-making

Joining systems of thought and action – draft 12/10/17

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Abstract

It is common to use formal or informal systems thinking (ST) to guide systems making (SM). One style is to use systems of invariant rules, as in the hard sciences, for guiding engineered applications. Another style mimics evolutionary development, using stepwise learning and improvisation to develop a system of thinking as things are being made. Examples include architectural design, scientific research itself and the practice of "action research" (AR). They all use improvised pathfinding to develop their end results, the subject of the paper. Both deterministic and improvisational ST for SM are widely found in differing roles, each having capabilities the other lacks. We start with simple models such as step-wise improvisation for adapting recipes when "making dinner". Another example is Robert Rosen's model for how cultures learn to work with nature, like sciences, by turning attention back and forth between theory and nature as they develop their own languages. The modern history of the systems sciences and their practices of ST for SM is reviewed as groundwork for potential AR applications, then a new paradigm of "natural systems thinking" (NST) is introduced, using commitments to "critical awareness", "emancipation" and "methodological pluralism" for working with natural systems.

Keywords

systems thinking; systems making; complex systems; action research; natural systems thinking; pattern-language; systemic practice; organizational change.

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relative figure scales: #1=1, #2=1, #3=.73, #4=.73, #5=1 #6=1 #7=.91, #8=1, #9=1

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I. INTRODUCTION

We start the story from the ancient past. How crafts originally developed would have been by people building up and passing on lots of versatile insights for working with nature, a kind of systems thinking. Showing a novice just the right way to chip a stone, cure leather or cook pigments would pass on those somewhat magical powers and the way if thinking about them. Over the centuries those accumulations of otherwise unrecorded skillful ways of thinking would have been central to the rise of civilization. Saying those things is a kind of logical speculation, of course, associating a kind of ancient 'systems thinking' with practices of complex 'systems making'. I hope it is also understandable enough to serve as a model for proposing reasonable hypotheses by illustration. It helps tell a story that anyone might understand from their own experience, and affirm or question as they read. In the end it is hoped such simple models do connect with familiar experience all tie together.

As societies developed, numerous specializations for related kinds of expert methods would have produced new divisions of labor, adding to the complexity and capabilities of social systems. How the arts were first taught and passed on would have been by demonstration and practice. Over time other arts would form reduced to rules and definitions, like techniques of accounting or navigation, marking a division of labor between the systems thinking of using rules and definitions and of learning by demonstration and practice.

The general practice of describing nature with rules and definitions seems to have come from Greek philosophy, particularly Aristotle, Plato and other philosophers drawn to abstract theory. Modern deterministic science developed in the 17th and 18th century with the work of Descartes and Newton among others, demonstrating the practical use of representing nature with abstract theory. Then in the 19th century the method demonstrated its world changing economic power, using theory and accounting for exact prediction to create machines using heat and electricity.

I take this historical approach is to show how one can refer to "systems thinking" in history as an implied informal form of complex thought, from which more current formal ones would have needed to develop. I do not mean to say that people of the past used what we now know of as 'systems theory', though. Wikipedia also mentions "systems thinking" as going back to antiquity too, offering a precedent for that usage. It is what I call a "practical reference", in this case referring to the practical necessity of traditions of artful thinking learned and passed down for generations to accomplish the feats of antiquity. There may be little or no other record than the artifacts, but they stand as clear evidence of a long heritage of developed systems thinking (ST) for systems making (SM).

As the scientific method spread it was found to also work well for chemistry and astronomy among other fields, but less well for sciences like biology, medicine, economics and ecology. For psychology and sociology it seemed to work rather poorly, and for other essential crafts such as entrepreneurship and design to not work at all. By all counts it was the great appeal of controlling nature with fairly simple rules and its economic success that inspired the great machine age of the 20th century and a modern world made in the image of deterministic science (Wilson et. al 1986).

Deterministic systems making as for building a steam engine, a steel building frame or a propeller, exact specifications need to be followed. The fixed specifications for the design remain unchanged and the improvisation needed in making the product is minimized. That characterizes what I call the "deterministic style" of ST for SM. What I call the "adaptive style" of ST for SM is the reverse, a process of discovering a design in the process of making choices while producing it, the main subject of the paper. That is the common way of working in business, architecture and design. Natural growth is also a process in which a design evolves as it develops, both for organisms and for ecologies and cultures. For manmade things both improvised and deterministic parts are usually needed, so the difference depends on which style takes the lead. In the course of introducing and exploring the place of adaptive ST for SM two particular methods will be given more attention. Those are "action research" (AR) first developed by Lewin (1947) for guiding adaptive social change and "pattern language" (PL) first developed by Alexander (1977, 1979) for focusing the holistic purposes of all kinds of design.

II. BACKGROUND ON ADAPTIVE ST FOR SM

Research Method

For this seemingly common but little studied subject of how systems thinking connects to systems making I use an exploratory research method, approaching it from a number of different directions. For illustration I use simple or familiar models, traces of data on developing scientific methods, citing of related literature and suggestions of possible new directions. What develops is a broad view of the connections between our mental models and our quite different working methods. Searching for ways to illustrate the ideas turned up a variety of new insights too, adding to the length and broadening the view.

Well known to scientists but less known to others, research methods of all kinds involve a lot of accumulative exploration in the research process, building on patterns of interest to see where they go. The goal in most scientific fields is to have explorations lead to experiments to settle key questions that others can repeat, and only then report on the results. The explorations recorded here could possibly lead to research experiments but the focus is really more on looking from many directions at how systems thinking and systems making evolve together.

Adaptive Systems Thinking and Design[2]

It appears that the more formal methods of adaptive ST for SM, like scientific research, product design and AR, would have originated with the more informal methods. Those would include familiar kinds of creative work like "making dinner" or "tending a fire". Doing things quite commonly requires regular rethinking while doing them. There may be set recipes to follow for some parts of making things, but it generally takes creativity to get even fixed formulas to work. When cooking a family meal a cook starts with an outline of what to do and then makes repeated adjustments for available ingredients, to suite individual tastes, for creative ideas, to finish on time and simplify things as needed.

Much the same can be said for implementing a business plan too. Industry conditions, partnership 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 you strictly follow. It really serves as a condensation of prior thinking from which you improvise to suite conditions and new thinking as it develops. The intent is there from the start, a very important guide, but how to make the actual steps only becomes known as you do them.

Some of the same pattern is seen in the least planned things we do, like "making friends" or "having fun", which usually start with a spontaneous thought or feeling that then builds and changes with the relationship. The same applies to "making a home" or "making a place" for things in your home. There tends to be a first image and inspiration that guides the process as the objective, something like a "seed pattern" to get things started. The same applies to a

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[2] The term "adaptive systems thinking" has some current use for practical problems like the design of clinical trials or negotiated resource management, found by a Google Scholar search filtered to exclude links for "complex adaptive systems": https://scholar.google.com/scholar?start=0&q=-%22complex+adaptive+systems%22+%22adaptive+systems+thinking%22

business going about making its home in the community, and to creating a business culture in which employees feel at home. All of those involve a process of learning while doing that starts with an idea for systemic change that evolves as exploratory steps toward the end develop by adaptive innovation.

For business products or architectural design or for multi-stakeholder partnerships for environmental problems complex teamwork is needed. The work still originates with some simple idea but then requires a more formal process of coordination. The need is to assemble effective teams of people from somewhat differing cultures, with differing abilities and 'intelligences', with an organization letting them both work independently and together. Generally that takes a pause in the work so the differing contributions can be presented for others to understand and then see how all the pieces of work fit together. How to do that complex coordination is often becomes highly refined, but may also be hidden from outside view. After the coordination meetings everyone picks up their work with new insight into where the whole team is headed and how to proceed with their part.

For complex designs the most important work is in the earliest phases. That is 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 highly conceptual, focusing on the essential character of the "brand", the "place" or "quality" of the work, perhaps spoken of in a language of metaphors unique to each project, that most of the team needs to understand. To speak that language a work team needs both social and productivity 'chemistry' to be able to "bounce off each other" and follow the many changes in the whole design in their minds. Then as they later work on their independent parts everyone can be working in the same direction.

Prototyping is often done for elements to be emulated throughout, making various models, testing how differing materials go together, trying out critical components, parts of software, test kitchen samples, test focus groups, town halls for response to environmental plans, test runs for new plays, test stump speeches for politicians, etc. It is a process that goes back and forth as designs develop and continues all the way through final implementation, when the end product finally "jells".

Stepwise Processes

A very general rule, like a 'law' of organizational development, is the need to start with small steps that lead progressively to bigger steps, and then back to smaller steps again. Organizational development just cannot begin with big steps, but needs to build up to them. The process of building up to big steps then needs to reverse, to complete the change with smaller finishing steps rather than cease abruptly. It is a matter of organization needing to first build up structures and then fill them in, as natural as starting with a seed to end with a plant.

That characteristic crescendo shape of stepwise development is perhaps most visible in how growth develops, of plants and animals, of businesses, cultures and even storms. They all generally begin and end with small steps having a swell of big steps in the middle, needing to build up in sequence to coordinate. You see it in the kinds of complex teamwork mentioned above, starting off with a simple intent and finally ending with small details. You see it in how a successful year or semester of schoolwork develops too, starting off with easy work and then picking up a steady fast pace to then ease off again at the end. You see the same pattern in the emergence of cultural movements, whether social, artistic or technological, and both in the growth of organisms and businesses. Even normal conversations tend to pick up slowly at first then taper off at the end as they conclude, as do personal relationships. It is such a broad pattern there must be a very natural reason for it, and enduring part of making things that is part of nature.

The order of the steps in making things is usually important too, as a building first needs foundations before floors and walls, and then needs the roof before interiors and finishes. A business needs to be built in stages too, using a start-up process to assure the productive use of its seed capital, followed by its immature and then mature growth, much like an organism needs to have an egg fertilized to begin its immature and then mature stages of growth too. Subjects in math need to be taught in order too, like breaking a link in a chain if concepts needed later are left out. In a group conversation it may not seem to make much difference who speaks in what order, so long as everyone gets to speak, but conversation is also sequential, and appears to change direction with everything said. These and other common patterns of accumulative design (Henshaw 2015) are very useful for understanding what it is that systems thinking needs to coordinate with for systems making.

Rosen's model of the Sciences

The theoretical biologist Robert Rosen (1991) developed a very useful model for understanding how science works, portraying science as studying patterns of nature to translate into formal scientific language. In Figure 1 Rosen's original diagram is at the bottom right, showing the "formal system" as involved in "encoding" natural patterns and then "decoding" the formal language into physical effects again. It is a general model for the ST for SM of the sciences.

On the left in Figure 1 I'm generalizing the model for all cultures, as each develops their own language for working with nature as its 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 the accumulation of experience and improvised practices, like anthropology or archeology, design cultures like architecture and lots of other professional and social cultures. The main point of the diagram is to show that cultures develop their own separate languages and so having no automatic way to connect, as each comes to represent a different paradigm for relating to nature.

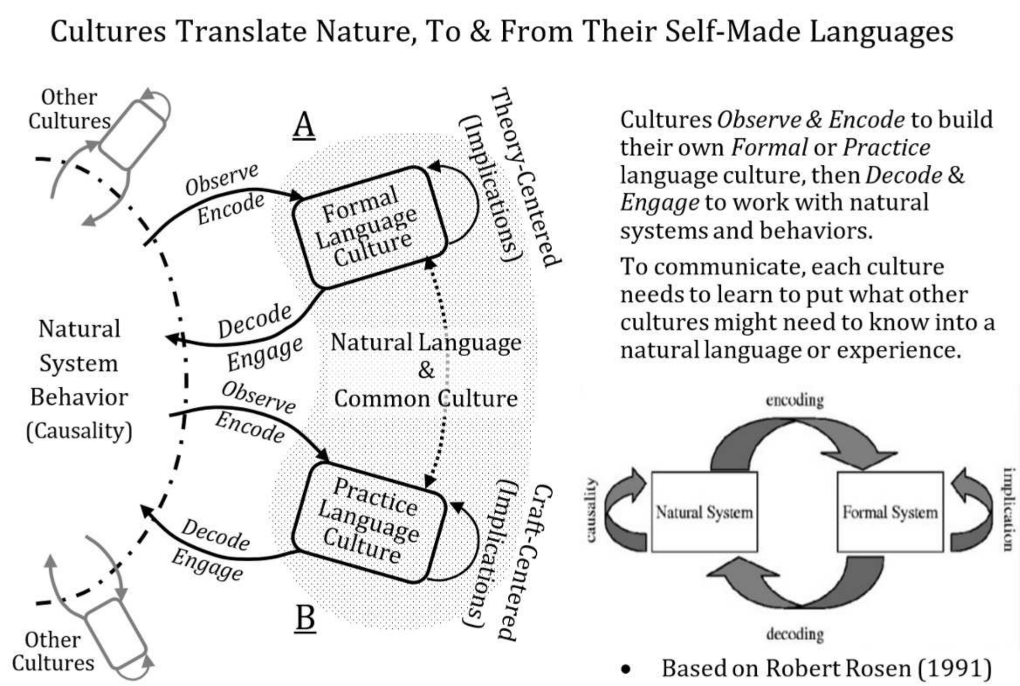

Figure 1. Separate cultures and their separate languages for working with nature

Sometimes theory-based and practice-based cultures have direct links, like the way engineers apply the theory of physics as a craft. Most cultures seem to develop languages just for communicating internally though, like most sciences and professions, different nationalities, religions, indigenous cultures. The sub-cultures and communities within them will share the same root, but like different branches on a tree may far apart in how they develop too. Maintaining separate languages seems to be part of how cultures retain the individuality of their interpretation of nature and connections to their own roots, even when they mix. It would seem to both empower their members and handicap them in relating to others.

What is very original about the Rosen model, is how it allows you to ask these new kinds of questions. Seeing how sciences seem to translate observation into theory and back also lets one ask what might get lost in translation, for another example. The languages for separate cultures would likely lose quite different things in translation too. That seems to be the case for different systems sciences, like physics, economics, sociology, anthropology and ecology. Each asks their own kinds of questions, using their own methods and looks at nature from their own viewpoints. Having a range of viewpoints is usually thought to make a better way to understand reality, but for cultures creating separate languages it seems as likely to make them blind to each other.

Physics, for example, seems limited to asking mathematically definable questions, economics to asking financial questions, sociology, anthropology and ecology to asking their own individually tailored kinds of questions too. Those differences also seem to come from focusing on the questions their methods are best as finding answers to, further steering each away from learning from each other. This apparently natural separation of different paradigms of thinking seems closely related to Kuhn’s (1970) conclusion that scientists tend not to adopt new paradigms in their own fields, but to cling to the paradigms they built their careers around.

That different cultures develop separate ways of interpreting nature also seems to give them little to say to each other. Very interestingly this apparent natural inability of cultures to communicate seems taken for granted and to go unnoticed. That fits the roles in the tale of the “blind men and the elephant” with each culture making its own separate way of seeing the one elephant. That each culture acts self-sufficient and self-satisfied is the puzzle, seemingly the rule even when other cultures develop very different useful insights. Like the “blind men and the elephant”, when cultures comes up with different answers they do not question their own form of knowledge.

Action Research as a Model of ST for SM

The practice of action research arose as a cycle of adaptive ST for SM first named by Lewin (1946, 1947) who 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 et. al 2009), alternating the phases of work and research so the subjects of the study could also be included in the researchers who studied the transformations they took part in.

Only a neutral facilitator would be needed to make the process self-contained (Reason & Bradbury 2006; Ison 2008) as participants turned their attention back and forth, between the phases of work on relationships and phases of research and planning. Because individuals come with very differing worldviews and abilities, 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, as well as for both people who Heron called ‘Apollonian’ (goal driven) and ‘Dionysian’ (spontaneous and reflective) (Heron & Reason 2016). The makeup of work groups might also include people not only having different “intelligences” but also understanding the world from differing professional or societal cultures, making it a challenge to maintain communication and cohesion.

The universal patterns everyone can understand are what need to be the bridge, personal relationships and common language, and the patterns of alternating work and review that are part of work any kind. After completing a section of work a sculptor pauses to examine their carving to plan ahead. A cook or a student does likewise, evaluating their progress as they move from one part of their work to the next. The same applies to negotiators and caregivers, all following a natural pattern of adaptive ST for SM. So AR can be seen as part of that very broad spectrum of systematic practices for following a very natural process. Examples of related practices that follow the same general model would include architectural design, business product development, government research and multilateral negotiation. In diverse teams each specialty may do most of its work independently but then bring all their parts together to review the project as a whole and set the next agenda.

Figure 2 shows that universal cycle as a model for AR teamwork with five phases of alternating adaptive ST for SM. The periods of work are shown as straight lines, to suggest periods of pushing straight ahead. The reviews are shown as large circles, to suggest stepping aside to look at things. In practice the end of a review is also the natural time for informal social gathering when casual sharing would extend the teamwork in preparation for the next phase of work. What makes this so creative for complex teamwork seems to be fairly universal. It allows individuals and smaller creative teams to work their own way and then come together to both inspire and coordinate with others on a common purpose.

The names of the stages of work (SM.0 to SM.5) are descriptive of the sequence of tasks, from the “seed” that gets the process started to the final packaging needed for “delivery”. This is also somewhat the way architects name design phases and deliverables according to the natural stages of work. There is always some “seed” of inspiration as the “first cause” for bringing a team together. Usually it is a stakeholder’s vision. For Architects the start may be a “napkin sketch” at a lunch or dinner meeting with a client, as an image to cling to as work begins. In other fields it might be “the pitch” from an entrepreneur for a new business plan, from a producer for a new theater production, or from an environmental activist promoting a new multi-stakeholder partnership, from educators developing new curricula or from a business planning group with of vision of how to change a business culture.

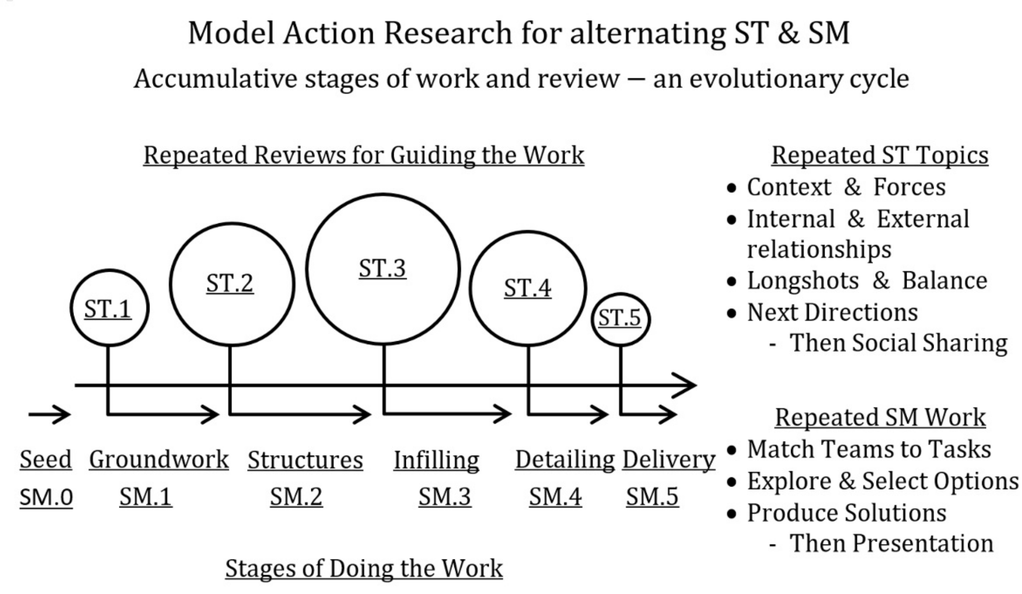

Figure 2. A general design for adaptive AR collaboration.

The cycle then begins with assembling the initial team for doing the “Groundwork” to both a) explore the environmental forces the project needs to work with and b) experiment with varied design concepts to see how they might fit, meet the true purpose and satisfy performance and sustainability budgets. That kind of holistic view is repeated again and again with each review. If a concept is confirmed its execution begins with SM.2, by differentiating the parts of the project as its "Structures". After reviews that is followed by the next big step of "Infilling" the structure. Then the project is brought to completion by the process of "Detailing" and then "Delivery" of the finished product for implementation. These names are generic that might well be changed to suite the circumstances.

The phases of review (ST.1 to ST.5) would be holistic reviews of the project that might include testing and research, focusing on the current stage of work and how it leads to the next. On the right in Figure 2 is a short list of fairly universal "Repeated ST Topics" for repeated holistic review: 1) the "Context" and its causal "Forces", 2) the "Internal" and "External" relationships that matter, 3) the special opportunity and risk "Longshots" and whole "Balance" of project financial and environmental budgets, and finally 4) setting "Next Directions" for the work and "Social Sharing" at the end. Below that are mentioned some "Repeated SM Tasks" for each phase of work such as: 1) to "Match Teams and Tasks", 2) "Explore and Select Options" 3) "Produce Solutions" and finally to make the next 4) "Presentation".

Each actual project would develop its own set of alternating work and review practices, suited to the customs and choices of the organizers and various methods borrowed from. That might vary considerably. Other core social science methods that might be used for organizing the process include Soft Systems Methodology (SSM) (Checkland 1999), "Learning Organization" (Senge 2006) and the 'SCRUM' software development practice (Schwaber 2004). Another is Alexander's highly versatile architectural pattern language (PL) (1977, 1979) method for focusing the design purposes of any ST for SM process, as further discussed in section IV.

All of these are variations on the same AR theme for steering adaptive ST for SM. The most important values are what the participants bring to the process. What is possible depends a lot on how a team is brought together to present its work to each other and seek new direction. People need to articulate what they've been working on in private so the team as a whole can envision the work they need to coordinate together. That inclusive sharing also provides social affirmation and integration for the team while mixing the varied ways each member raises questions. The combination is then what allows everyone to understand the new directions for the work agreed to.

III. 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 use Google's database of terms found when scanning the books of several leading libraries. What are called Google "Ngrams" [3] allow you to quickly draw a publication history of books containing chosen search terms reflecting various emerging or passing cultures. For example Figures 3 & 4 show curves for selected terms associated with soft and hard systems sciences, from 1930 to 2008. The curves are seemingly associated with emerging paradigms of ST associated with practices of SM[4].

What makes these history traces useful are the stories they sometimes tell about the rise and fall of the associated cultures and their emerging paradigms of thought. For example in Figure 3 you see a quite dramatic difference between the publication record for "operations research" (OR) and "action research" (AR). Both first appeared in the early 1940's but then developed extremely differently. What jumps out is the meteoric rise of OR in the 1950's followed by a

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[3] Google Ngrams https://books.google.com/ngrams/
[4] Terms for waves of more recent ST for SM: (robotics, neural networks, artificial intelligence, social networks, high technology) show similar curves but that discussion is outside the present scope.

sudden and then continuing decline. That is totally different from the long and fairly steady accelerating growth of books referring to AR over the same period.

That dramatic difference is interesting in itself, but also says there is some big story to tell, one that would take probing other sources of data to piece together. Reading history from single data curves is tricky in any case, but especially for reading Ngrams. It is not actually clear what the Ngrams themselves trace, just recurrent phrases, so they always need to be interpreted contextually. There may well be various groups using the same terms with different meanings for example. 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. I was quite surprised by both the OR and AR curves, actually, and unable to guess what was behind either at first.

After some research I have an educated guess about the unusual rise and then fall of OR. It takes a little interpretation of the reference I found, but it seems to have been inspired by what we'd now call an "irrational exuberance", a great excitement with using mathematical models for business management (Simon 1958). It seems logical that such a belief 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 to study work environments as a whole (Ackoff 1979).

A better understand the long growth of AR came from doing a few Google Scholar searches looking for "action research" publications for various years. What I found was a split in the cultures using the term. For both early and recent publication on AR the top search pages related to education, with uses for social science hard to find, apparently due to the Google bias caused by filtering out all but highly ranked pages. I also briefly searched for what AR was currently most used for in education, finding a suggestion of use is by groups of teachers, for extending their teaching skills (Stringer 2008). That could be associated with teachers facing rising demands for performance from society. If so, it might be worthy of study.

Some of the systems thinking terms I included in Figure 3 could mean different things to different people. The term "systems thinking" itself might be used either in the hard or soft systems sciences, or even in popular literature. Why I put it with the soft systems terms in Figure 3 is that the shape is a lot like two others there, the curves for "critical systems" and "soft systems". All three have a plateau centered on about the year 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 4) seem to have that shape. For similar reasons I included "general systems" in the terms of hard systems, for having a similar shape to others there, though the use of that term is also mixed.

Interestingly the earliest modern use of the phrase "systems thinking" in the Google database of scanned books was in 1937. That was followed by a flurry of uses in the 1940's and then the great wave of popular use beginning in 1959[5]. The earliest specific citations I could find for it were both in the field of education, in 1953 (Brown) and 1957 (Smith). What triggered its great popular use in 1959 is unclear, but might tell an interesting story. It could have been picked up as a delayed reaction, to popularize the difficult but revolutionary ideas of Bertalanffy and Boulding proposing General Systems Theory (1956; 1956).

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[5] Ngram - https://books.google.com/ngrams/graph?content=systems+thinking&year_start=1860&year_end=1965

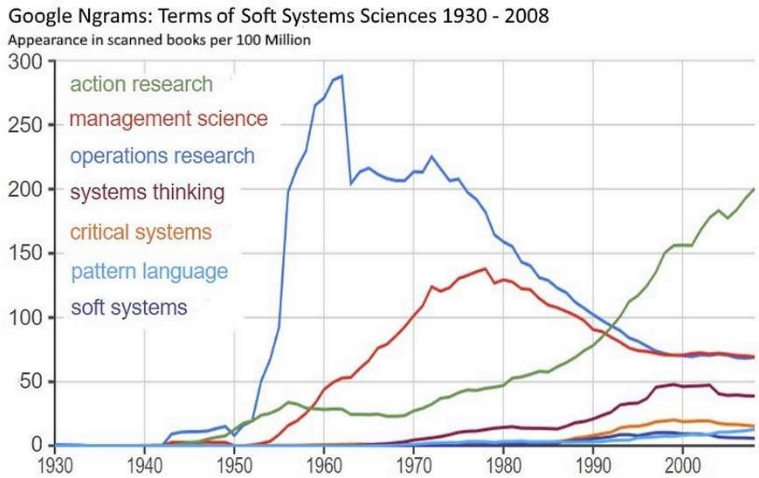

Figure 3. Ngrams for terms of soft systems science

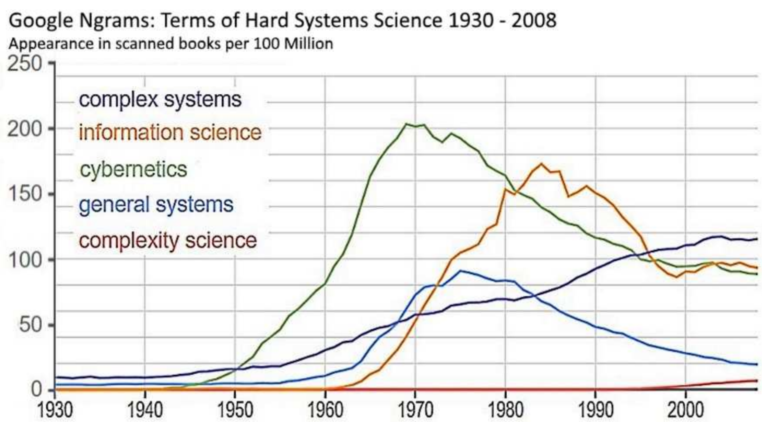

Figure 4. Ngrams for hard systems sciences

The most common general shape in the collection is interesting too. Eight of the twelve curves show an initial rise followed by a decline to a stable level. It is just a guess, but it could reflect the initial excitement with each new field as untested directions are explored. It seems logical that excitement could naturally fade as the field settles into its permanent place. Just one of those, "general systems", may be slowly fading toward zero, as if unable to mature and find a lasting place. I've studied the history of general systems theory for years, originally being caught up in the excitements of the field myself. Perhaps its lasting problem was being open to so many experimental approaches that the term gradually lost its practical meaning. The origin of general systems theory is still of interest, having been central to the early branching of both the hard and soft systems sciences, a subject that will come up next in reviewing literature of those fields.

Out of the 12 curves four did not fit that most common shape. As of 2008, three of them were still in their period of initial rise, exhibiting something like exponential growth: "action research", "pattern language" and "complexity science"(CS). The large scale and continuing growth of AR is clearly important. Though smaller the curves for PL and CS seem to still be growing too. AR and PL are also of interest for historically being adaptable to many fields and growing partly by spreading to multiple disciplines. The one exception to all these patterns is the curve for "complex systems". That is a term used by all the systems sciences, and in public discussions too. So perhaps its slow and steady climb throughout the period reflects a term entering the common language, rising gradually as the name of the common subject.

Hard Systems Sciences.

For the older hard sciences had a long history of remarkable economic success, developing theory to make technology for controlling nature. The hard systems sciences that emerged in the 1940's and 50's continued that, but developing theories of information, communication and control. That produced both lots of important technology and the spread of variations on general systems theory to all the other sciences. It also drew attention to unsolved problems science still struggles with, such as understanding the self-organizing systems of nature like cultures, ecologies, and economies. Such individually developing types of complex organizations display emergent properties of their own we still seem to explaining as Aristotle did, just saying "the whole is greater than the sum of its parts".

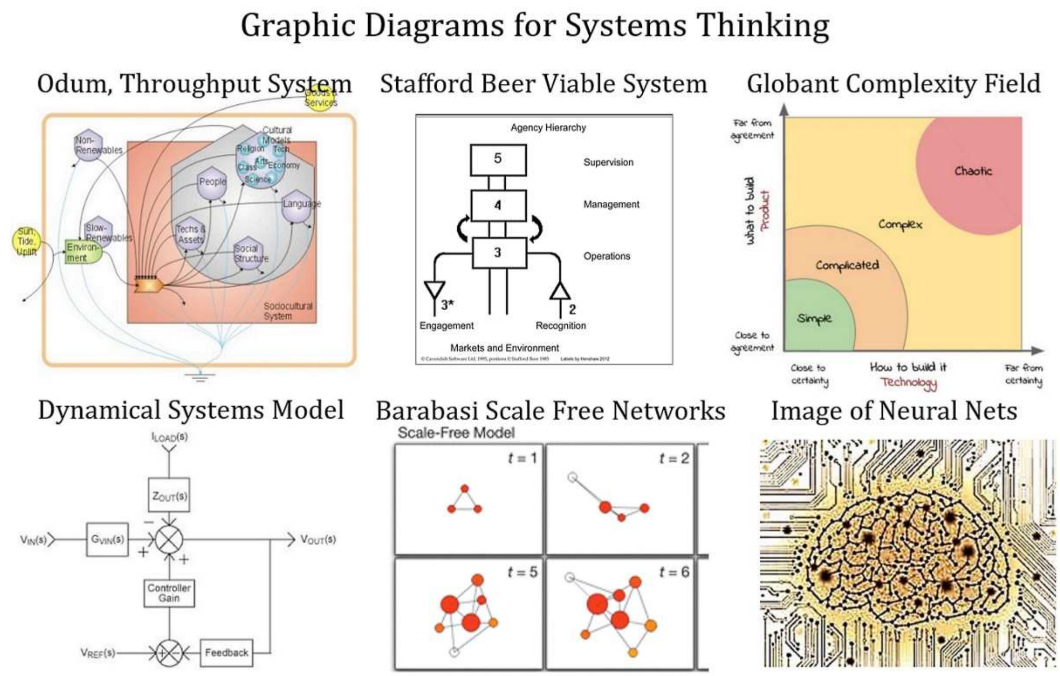

Figure 5. Conceptual Diagrams of Systems-Thinking in the Hard Sciences

Information and control theory still produced tremendous value though, 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 artistic, cultural and economic innovation around the world. That huge spread of wealth produced by the hard sciences clearly offered improved human welfare. Sadly it was also mirrored by new kinds and scales of poverty, war, ecological and cultural disruption too, as evidence of something lost in translation in creating our best methods of ST for SM.

A short list of milestones for the emerging hard systems sciences begins with Wiener's cybernetics (control theory) (1948), followed by Shannon's theory of communication (Shannon & Weaver 1949), and then Ashby's information theory (1952, 1956), forming the basic building blocks of abstract systems science. A unified framework for them emerged in the 1950's called "General Systems Theory"(GST), led by the biologist Von Bertalanffy and the mathematical psychologist Rapoport (1956) and separately by the economist Boulding (1956). That rapidly expanding field was then more formalized in the 1960's by Simon's Architecture of Complexity (1962) and Von Bertalanffy's second book on the subject (1968). General systems theory held great promise as a way to tell the rich stories of how the complexly organized things of life really worked, and a great diversity of new branches of systems science sprang up in every scientific discipline (Henshaw 2010a).

A few of the later milestones for hard systems sciences would have to include the discovery of non-equilibrium thermodynamics by Nicolis & Prigogine (1977) as a basis of the deterministic study of self-organizing systems, and the extension the entropy principle to complex economic systems by Georgescu-Roegen (1971). 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 et al 1982), and the theory of fractals (Mandelbrot & Pignoni1983). The foundation for computer simulations of life was laid by the study of "cellular automata" (Wolfram 1984), and the development of "non-linear neural networks" (Grossberg 1988) laid foundations for learning machines. Great advances in using these new fields of systems mathematics like "neural networks" (Cochocki & Unbehauen 1993) then led to new methods of simulation called "artificial life" (Langton 1989) and "artificial intelligence" (Russell & Norvig 1995), for emulating the behavior of systems of autonomous agents, leading to today's robotics. Together those fields seemed to open the door to explaining nature with a "phase space" of self-organizing "far-from-equilibrium" equations (Kauffman 1993). Large parts of the field were then unified by the development "complex adaptive systems" (CAS) (Gell-Mann 1993; Holland 1992).

The deep problems with understanding the systems of nature remained, however, with getting emulations of nature to really work and with trying to discover where the organization and emergent properties of self-organizing systems come from. It presented a sufficiently fundamental problem to bring into question our whole method of defining the question, perhaps to even question whether nature works by information. David Pines, one of the founders of the Santa Fe Institute of complexity science, put the problem it 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." (Pines 2014)

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". How to define the organization that does that, though, seems still beyond reach using the methods tried so far. Consequently some new way of learning about how natural complex systems develop their unique emergent organization and properties seems to be needed.

Life Systems Sciences

One place to look for other approaches to systems science is in the older fields of systems study, like economics, anthropology and ecology. Some of their methods were developed well before physics began to emulate self-organizing systems axiomatically with information and control theory. One of the foundations of the life systems sciences is to take the organization of nature simply as fact, and carefully record its emergent properties, the way even physics developed before the 20th century. Another foundation of the life systems sciences is the use of simplified models, to serve as general explanatory principles for how whole systems behave. A classic example is the 130 year old economics observation of Jevons (1885) of a simple but counter-intuitive emergent behavior of economies. He noticed that improving the efficiency of technology to use less resource per task tended to increase (not decrease) total resource use, apparently due to the multiplying numbers of tasks that could be done. That efficiency makes technologies more profitable to use seems to be the source of it, increasing resource demand by expanding the economy as a whole (Polimeni et. al 2008; Henshaw et. Al 2011).

Recognized behaviors of whole systems serving as general explanatory principles for the parts have often been building blocks of science, like in the work of anthropologist Margaret Mead (1973) who documented that human cultures are socially inherited systems of information. Ecology also relies on simple explanatory models that aid in the understanding of complex environmental systems (Odum 1983). You can see it in the beautiful way Odum (1950) defined ecology, as the study of large entities (ecosystems) at the "natural level of integration". What I see as important is that Both Mead and Odum use the explanatory principles they observe to define the terminology they use, “culture” and “ecology”, and so coordinate their mental categories with observable units of natural organization, not abstract definitions and theory.

Another example is the popular Panarchy model of evolution developed by Gunderson & Holling (2001). It associates adaptive renewal in ecosystems with the seasonal cycles of ecological decay and adaptive rebirth. As an overarching law of nature the principle also seems to somewhat fit the evolutionary succession of technologies seen in economies. Useful explanatory principles that fit what we find in nature are the basis for most business consulting too. One example is Snowden’s Cynefin method of business path finding (2007) identifying different styles of decision making associated with the state of the business environment, whether “simple”, “complicated”, “complex” or “chaotic”, with business strategies for each. These kinds of simple models of for patterns of design found in nature help with recognizing what is different in patterns of organization in reality one needs to work with.

Social Systems Sciences

The milestones of the modern social systems sciences could begin with Baskerville & Meyers (2004) citing the foundation of AR in the 1930’s as in the intellectual premises of Pierce, James, Dewey and Mead. Baskerville cites 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) originated “action research”, while similar experiments were also being done at the Tavistock Institute. Those combined the treatment of battlefield trauma with experimental changes in the therapeutic environment. That made the researchers part of their own experiments (Trist, 1976). Very early AR practice was also found being used in education (Corey 1954).

Interest in operations research (OR) was breaking out at about the same time as AR (Figure 3), but focused on the use of mathematical models for business (Simon 1958). It also attracted some of the leading thinkers who would later break away from that preoccupation (Churchman, Ackoff & Arnoff 1957). The early influence of general systems thinking on the social sciences seems evident in the visionary thinking of McGregor (1960, 1966). McGregor proposed a rearrangement of traditional business organization, incorporating the new social principles of Argyris’ “Personality and Organization” (1957) and Maslow’s “Theory of human motivation” (1943, 1971). What McGregor called “Theory X” was the style of business management that treated workers as naturally indolent and needing to be controlled. The new model he called “Theory Y” was based on individual self-realization. That model is still a guiding vision for workplace and societal development today, even as world society also now struggles with strong opposing forces of ever growing inequity and waves of social and workplace insecurity.

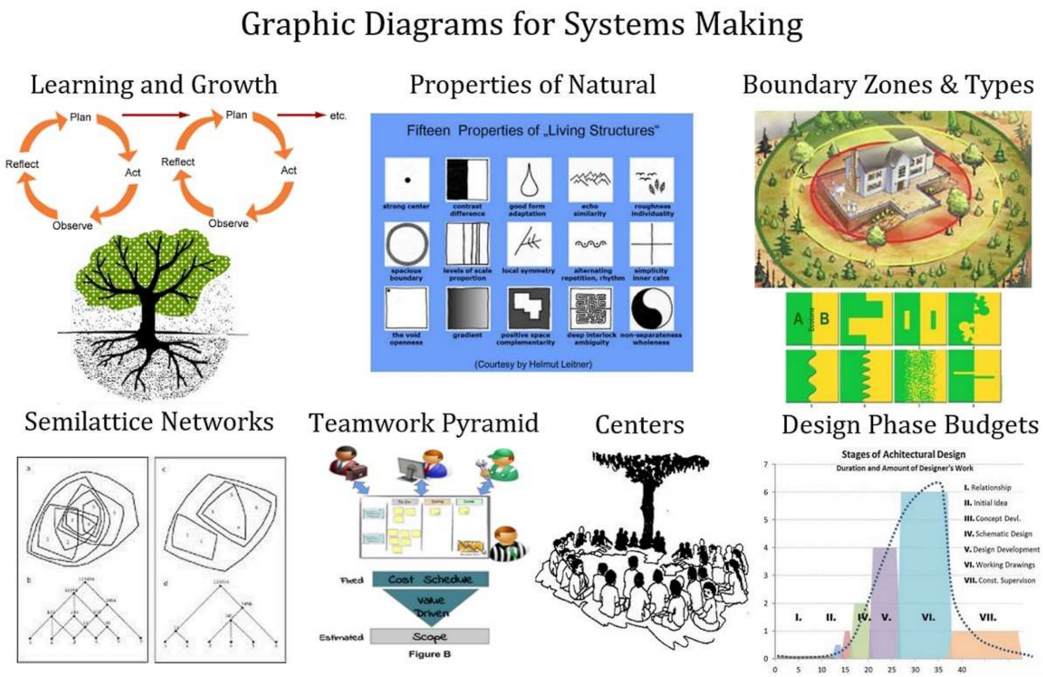

Figure 6. System Making Concept Diagrams

Important systems principles for working with natural subjects were added by Argyris, such as "Double loop learning" (1977), offering a discipline for both questioning one's research methods and assumed objectives. Churchman (1979) observed that social "boundaries" need not be "lines", but could be any kind of relation of inclusion or exclusion, such as "personal space", "niches", "cultures" and "neighborhoods", etc. A great many organizational boundaries are diffuse like those. Ackoff (1979) wrote "The future of operational research is past", breaking with OR and the overuse of equations for business. In the same year Churchman (1979) demonstrated the value of critical ethical awareness in discussing "The systems approach and its enemies" as the discussion of "critical systems" and "soft systems" thinking (Figure 3) were emerging.

In the 1980's and 90's several important innovations in systems management gained prominence. One was Checkland's soft systems methodology (SSM) (1981, 1999). SSM focuses on defining a learning method for business fully integrating AR in its practice (Baskerville & Wood-Harper 1996). It also emphasized the use of natural language rather than jargon and use of multiple system models to compare their fit with reality. A second was the interdisciplinary field of "critical systems thinking" (CST) (Flood & Jackson 1991; Midgley 1996; Flood 2010). CST emerged as a set of high level standards for applied systems thinking, with central commitments to "critical awareness", "emancipation of subjects" and "methodological pluralism".

The design fields also produced major advances in systems learning. Alexander's pattern language (1977, 1979) had roots in the 1960's and its wide use developed in the 1980's, spreading to various fields. Its greatest impact was on focusing the purposes and methods of software development (Rising 1998; Tidwell 1999). Two other important innovations in organizational development were Senge's five dimensions of "Learning Organization" for business (1990, 2006), and the 'agile' approach to business management and software development (Conboy & Fitzgerald 2004; Schwaber, 2004). Jackson's "creative holism" (2003) makes a sixth noted systems thinking approach to advance organizational learning as its theme. 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 too, especially in education (Carr & Kemmis' 2003; Stringer 2008).

Notably PL, CST, AR and 'agile' methods can all be used to produce hybrid methods in combination with others. They can also be used by varied professions and tend to spread from one community to another. It makes them versatile and mobile, somewhat like viral technologies with many applications. An illustrative example of that is the home use of 'agile' business methods for families (Feiler 2013), with the aim of empowering children and enriching family communication. Like a simplified practice of AR for the home it asks a family to regularly revisit 1)"what is working well", 2)"what might work better" and then 3)"what to work on next", used along with check lists. As with all of these structured learning methods, the method itself is embodied in the culture and practice as much as in the texts. So picking up some of the culture and practice that goes with them is an important part of what make them work in practice. For example, you can get of feel for what 'agile' can do for businesses from recognizing what agile does for some homes, empowering the children in getting the family to work for them.

IV. NATURAL SYSTEMS THINKING

At this point we can look back and see sections I, II and III above as parts of a broad survey such as one might develop in the "Groundwork" phase of a related AR teamwork project. It might be for exploring some new direction in scientific ST for SM or to work on a collaboration between scientific methods perhaps. I do not specifically intend it to be used for such a project, but to offer that as a model for understanding the preceding sections as a context for what is to follow. The next sections on "natural systems thinking" (NST) are ideas for going further. You might call them three "longshots" to consider for use in the review and study phases of other AR applications.

Added Focus on Reality

What I'm calling 'natural systems thinking' (NST) aims at extending what is perceived to be a pattern of increasing focus on reality in both the hard and soft systems sciences. What is added is a more direct focus on the individuality of naturally occurring systems and on their sometimes recognizable organizational patterns of design. That makes it more about observing things than explaining them, recognizing their "natural level of integration" as Odum (1950) did. For its theory perhaps Goethe's somewhat formal precept would be enough to start, saying: "Search nothing beyond the phenomena, they themselves are the theory" (Riegner 1993). My own research in the 1970's accidentally started from that approach. I became fascinated by the "S" curves of organizational development seen in the emergence of individual natural air currents (Henshaw 1978). Doing a field study of microclimates I closely watched the crescendos of air current development, changing slowly at first then rapidly, then slowly again as they developed their complex organizations. I recognized that as common for development patterns of growth and maturation.

Three additional principles for NST are borrowed from critical systems thinking (CST), "critical awareness", "emancipation" and "methodological pluralism". For NST they are applied to recognizing the individuality any subjects or circumstances being observed or worked with, as they are themselves. Similar to CST, for NST 'critical awareness' involves challenging assumptions about natural systems and considering them from various points of view to better understand them. For NST the principle of 'emancipation' for observed systems would include recognition of their individuality, having interest in their roles, constraints and dependencies and in the implied interests of the systems they are part of. Mistaken attributions of human cognition or intentions should of course be avoided. For NST 'methodological pluralism' means using a variety of exploratory methods to consider natural system subjects from multiple perspectives.

For example, NST could help businesses focus on their natural structures, such as their three individually different primary cultural networks: ‘management’, ‘social’, and ‘productivity’ (Pflaeging 2014) (Table 1). Each of those primary business cultures would have its own language and ways of working with the others, but born as a collaborating cluster. For the roles of each to be recognized by the others would help them all work more smoothly, and be important include in analytical business models like that of Al-Debei & Avison (2010). There are also three dimensions of interpretation that the primary cultures of a business are subject to, the ‘natural world’ view, ‘social world’ view and ‘subjective world’ views (Midgley 2016).

Pflaeging.(2014)	Midgley (2016)
Three Natural Domains of Working Business Organization	Three Natural Domains of Perceived Business Organization.
management culture	natural world
social culture(s)	social world(s)
productivity culture(s)	subjective world(s)
& connections	& connections

Table 1. Natural structures for developing natural categories of systems thinking,

It seems less important to sort out the added complexity these added dimensions create. It has always been there. Learning to move from one view to another is what might help bring out the right issues when friction, neglect or conflict is experienced. The general benefit is then having mental categories that better fit to the natural structures, helping to distinguish them, identify more details, and build up a more holistic view. As Bateson observed (1972 p64) it grounds perceptions in actual subdivisions of the natural world, rather than in stereotype labels for judgmental political, academic, social or occupational points of view. There are lots structures of natural design that deserve attention of this sort, often “hidden in sight”. More of these are discussed in the related research paper (Henshaw 2015).

It is also a challenge to recognize emerging cultural worlds “in the wild” as they define their own realities and ways of living. We might notice and learn to appreciate them from hearing their distinctive internal languages, noticing the boundaries of their domains, and tracing their histories of development. If you see them as intruding as we often do that is harder to do, of course. What I find a little easier to recognize is their patterns of “home making”, which gives me a mixture of “inside” and “outside” perspectives. Home making is what any family, business or community culture does to establish its independent place in the world. What we first react to as ‘strangeness’ as when going into someone else’s home, or into someone else’s business, is their way of making the world familiar. From that view the tremendous variety of ethnic, business and family cultures all operate much like ecologies do. Maybe most important, seeing cultures as “homes”, how it builds a point of view of them from both inside and out.

To help distinguish between natural world and subjective world views NST also focuses on distinguishing between terms used with *conceptual intent* (subjective mental constructs) and terms used with *practical intent* (things defined by nature). Examples of practical intent are using ‘apple’ to refer to apples, ‘storm’ to refer to storms or ‘sorrow’ to sorrows, each term used to refer to something independently defined by nature. The idea is again to be able to change perspectives. The way we use words often confuses the intent, as by attributing our semantic meanings and emotional experiences to the related things of nature. Learning to work with nature, though, it is often important to tease the mixed intentions apart. What is natural is to switch from conceptual to practical thinking and back in ST for SM, as much as needed to clarify one or the other. Like when asking people to help clean up after dinner we are speaking conceptually, but people then normally take it practically and look around for what remains to be done.

Another very helpful use of NST is noticing the hesitations people have when switching from ST to SM. For example, a novice will be a bit frightened by the prospect of switching from conceptual to actual dancing, or from conceptual to actual swimming. When you only know how to do things conceptually there is a natural emotional barrier to doing them literally, not having a "feel" for how to start. When making investment decisions it is the same, or going through any other momentous change. What Keynes called "animal spirits" are needed to get you over the hump and move you into action any time you're taking naturally unpredictable risks (Akerlof, & Shiller 2010).

Radically circumspect

This way of switching points of view to consider many sides came from years of conversation and study that switched back and forth between the systems thinking of physics, social sciences, architectural design, and building. What finally bore fruit was the field study of micro-climates in buildings, that led to a general systems model of self-organizing transformations (Henshaw 1979), followed by years of research and papers on natural learning systems (Henshaw 1985, 2008, 2010b, 2015). Other references on how natural systems individually develop and behave include Alexander's observations in "A city is not a tree" (1965), observing that living system networks formed opportunistic ("semi-lattice") not deterministic networks, and his "A Pattern Language" (1977) that describes patterns of organization that are receptive to life. Jane Jacobs wrote remarkably accessible books on the organizational evolution of societies such as "The nature of economies" (2000). Among other good resources are Bateson's "An ecology of mind" (1972), Goodwin's books on patterns in evolution (1994), Meadows' insightful principles for "dancing with systems" (Wahl 2017) and the field of biomimicry (Benyus 2002).

The Heart of Pattern Language

Alexander's pattern language (1977, 1979) is a versatile practice for most any field for using the ancient practices of holistic architectural design. It focuses the purposes of design on the emergent properties of inviting patterns of organization. For example: having shops by a bus or train stop, park benches in nice locations, or public squares in the heart of a city, all attract enriching life experience. The design intent is to create patterns of organization in which things come alive, a combination of 1) a useful structure that 2) fits a potential of its environment. The combination of wheels and axels to make vehicles, or having separate but equal branches of government to make vital democracies, do that as well. What they all have in common is unusually effective structural designs producing unusually satisfying results.

In Alexander's language those kinds of special combinations both solve particular problems and spread "living quality" in their surroundings. These "expert solutions" are called "design patterns" and used as versatile guides for similar circumstances wherever they occur, a bit more complex than a "design principle" and more general than detailed instructions. They are also recorded carefully enough to include them in collections, so any reasonably skilled person in the field could understand and use them.

Some come from "mining" great solutions found somewhere and recording their essential features. Others are developed by recognizing a context in which there are "unbalanced forces", identifying where a well-made structure would provide a satisfying resolution. For example, one might have unbalanced social relationships in an office making everyone unhappy, recognized as a problem when people start calling it "lazy interns". With some observation and discussion a set of "unbalanced forces" might be identified as the heart of the problem. In this case the right way to balance the forces might come from giving the interns the right increased responsibility and competition for rewards. In another case it might be letting them specialize and work as a team. Both would be for resolving much the same unbalanced forces.

Pattern Language "Design Pattern" Model

Pattern Name	1. 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 7. Structural Ideals of Pattern Language Design

Alexander's process is outlined in the steps shown in Figure 7, a list of headings also used for recording the written descriptions of design patterns, sufficiently explicit so anyone in a similar situation can both recognize it and see how to solve it. Vitruvius spoke of great architecture is a mixture of "commodity, firmness and delight". Alexander's method for seeking the same kind of perfection is a bit more explicit and applies to more fields.

To use this way of focusing on highly valued design purposes in an AR project you'd raise the issues listed in Figure 7 during the research periods (Figure 2). To introduce it to a team you might just circulate Figure 7 with a paragraph on it in project literature, then plan a limited discussion of the questions for project reviews, keeping it simple to fit in. If successfully applied to social change it would streamline the identification of concrete goals and refinements, identifying new structure to relieve an imbalance of forces as for the example above of "lazy interns'. If it truly fits a higher state of social organization forms, bringing "living quality" to the business culture as a whole, Alexander's central purpose.

Design patterns and comments on them can be collected in text form or archived on a pattern wiki (Köppe et. al 2016). Various groups use their own formats. The format in Figure 7 is similar to the most common ones, but with an added focus on the middle three items, #3, 4 & 5, what I call the "heart of pattern language". That is 3) recognizing what "forces" are out of balance as the needed insight, 4) finding a fitting organizational structure for resolving them and 5) pointing to the functional and living qualities as intended benefits. As mentioned before it pays to learn about some of the culture from which expert practices like pattern language come from.

Often the key to greater success seems to be less the brilliance of the design, and more the rich observation of the 'context', step 1. A designed method for clearing the mind of preconceptions when searching an environment for how to work with nature helps to get things started (Henshaw 2013). Links related writings and collections of design patterns to study are available from the Hillside Group (1993-2017). A wonderful source for high quality design patterns for civil society is Schuler (2008). In the 1980's pattern language began to spread widely, making its biggest impact as a method for defining meaningful purposes for software development (Rising, 1998).

Reading Life Stories

To better understand growth and development we can find "story arcs" that fit their shapes to bring them alive, as a narrative form of ST for SM. It would only take some storytelling imagination and some study of the natural patterns of accumulative developments (Henshaw 1979, 1985, 2015). Finding a story that fits a pattern of change gives it both meaning and a chain of causation that is somewhat testable. That kind of test is done by just finding new information and asking if it fits the story, or suggests others. That could be done in the context of the review periods of an AR process. The modern idea of "story arcs" comes from Campbell's recognition of "the hero's journey"[6] (Campbell 1968) as a universal story. To stimulate the imagination Table 2 offers a list of other recurrent challenges and quests that as they play out would shape the story of a life or of an organization.

A classic CEO challenge is to find a new story to transform a business, such as: "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" [7] To do that she might develop a use for the story arc of "the little engine that could", for showing how the business could pull its strengths together and get some help to take on the challenge. The story is then something tangible to refer to that also stimulates the imagination. A good story is also a way to get people beyond the common problem that: "We do not see things as they are. We see things as we are."[8] That is often a real challenge for both individuals and organizations.

Life Story Arc's – 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 arc
novice's arc	tragedy in the commons	Tom Sawyer arc

Table 2. A few names for story arcs that might stimulate the imagination

Our own personal life stories begin with the circumstances of our birth and proceed with our childhoods and youth, leading up to our adulthood where we then take on the shifting roles in the world that leave our legacy. The "arc" of the story is both its central themes and a curve tracing the rising and falling action of the life experience. Non-fiction arcs are much the same as fictional ones, except based on actual events for which the story is an interpretation of connections. The curve might trace the "tension" or "progress" of the story, or for a business it might trace measurable indicators of "sustainability" or "man-hours" or "cash-flow". What holds either a good story or a life together is the *continuity* of the accumulating changes, how

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[6] Synopsis: A hero ventures into a region of supernatural wonder, achieves a decisive victory over fabulous forces, returning with the power to grant benefits on his fellow man.
[7] How stories Drive Growth: HSN - https://www.gsb.stanford.edu/faculty-research/case-studies/how-stories-drive-growth-hsn
[8] Widely used Talmudic saying: *Rabbi Shemuel ben Nachmani, as quoted in the Talmudic tractate Berakhot (55b.)* https://quoteinvestigator.com/2014/03/09/as-we-are/

one step follows and builds on another. Steps that do not connect, like out of place scenes in a script, are strong evidence of something missing, that you then look for. It makes associating physical growth or development with a story line a useful way to see where the breaks are.

Figure 8 gives three very general story arcs corresponding to the development and development curves below. The "Rate of Activity" curve is highest at the midpoint when the "Progress of Development" is steepest, as two ways to show the crescendo of change that is generally the central part of the story. The top story arc begins with "awakening" and ends with "resolution" having a journey in-between. The second describes the "dynamic" as going from "pos-feedback" (to get things going) then "pos-feedforward" (to make things to last) with the end of "resilience". The third describes the "stages" as "individuation" then "maturation" then "life", with the three arcs together, and the notes for the curves, describe the normal progress of beginning a life. When working on an actual project you learn to follow the stages so you can see if some part is not finding its individuality, or not maturing in pace with others, relating the deep stages of becoming with the necessary continuity of the arc of the story.

The Natural Life Story Arc / Growth & Development

Awakening	Rising Action	Climax	Falling Action	Resolution
(dynamics)	Pos-Feedback		Pos-FeedForward	Resilience
(stages)	Individuation		Maturation	Life

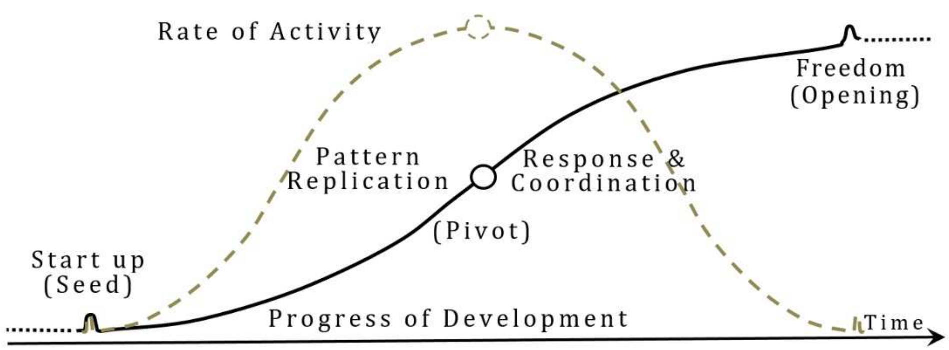

Figure 8. Main invariant properties of growth and development stories

The other invariant features of the curves in Figure 8 are the crescendo of activity in the middle (dotted line) and the "S" curve of accumulative development (solid line). The "start-up" seed begins the "pattern replication" for the emerging individual which then "pivots" to "response & coordination" on the way toward the opening and "freedom" at the point of becoming mature. In any real life it's a simple story, but a heck of a ride too. Actual history curves for life stories would normally have various ups and downs, and perhaps story detours as well. The whole story and the development process will both still fall apart without *continuity*. Sometimes the original start-up or freedom events are very clear and obvious. In other cases those are not easy to find. There is always something small like the "spark" that starts a new relationship or the point of "turning a profit" that marks the graduation to independence for a new business. Freedom is of course not absolute either, but just the point when the successful emerging system is ready to choose its own paths.

These curves are sometimes confused with mathematical equations, but these are history curves representing the most common progressions of growth and development. An equation does not even need continuity, nor does it need smaller scale "start-up" and "freedom" events. A building needs them though, ground breaking to start and giving the key to the owner to finish. Any office project needs them too, the suggestion that takes hold and kicks things off, the final shuffling of details at the end. Equations do not need to "pivot" in the middle either, to shift from replicating the start-up pattern to then respond to natural limits and coordination. Preparing a successful dinner, though does need that pivot in the middle, to go from starting to finishing things. So does any project, to come in on budget. These small scale features that punctuate developments are so very common in nature, business and life that a simple model like this includes them as things to look for.

Other Story Arcs of Organization Development

	Start up		Pivot		Completion
(growth)	Emergence	Differentiation	Integration	Refinement	Maturity
(building)	Groundwork	Structures	Infilling	Finishes	Occupancy
(learning)	Challenge	Exploration	Discovery	Mastery	Integration
(projects)	Planning	Testing	Execution	Completion	Use
(designs)	Concept	Schematics	Development	Details	Delivery

Figure 1. Story Arcs of corresponding development processes

Five more specific story arcs are shown in Figure 9 for “growth”, “building”, “learning”, “projects” and “designs”. To turn them into stories just read each list and think of how they characterize the stages from beginning to end, that make sense of the words. Substitute your own words as your way of describing the natural progressions too. For any of these six you could also find measurable indicators of development and the rate of activity, to construct or free hand the curves of the developmental progressions, for a past or current project. Examples of how to read Ngram data curves as stories of emerging paradigms of systems science were already presented, with “early exuberance” before settling down seeming the common pattern. The idea is to find evocative story arcs that seem to fit the circumstances. It both gives you a simple model for trying to fill in the blanks, like a useful hypothesis giving you something to test. In using it for an AR project you might start with assessing the problem and picking a goal, then come up with a few plausible story arcs for bringing it about.

V. Discussion

This review of systems thinking for systems making, of ST for SM, seems both a bit lengthy and abbreviated. I’ve approached it from many directions, laying the groundwork for a general approach while illustrating it with simple examples and a few advanced subjects. So the paper already contains as much discussion as seems needed, and a reader might just skim over the varied sections to refresh their view of how it all came together. The intent has been to look at the subject from many perspectives, using the exploratory method and to present a holistic view, while also trying to raise lots of good questions for use in diverse applications.

A list of hypotheses to recall some of the themes of ST for SM …

- Adaptive design during step-wise development is familiar in all kinds of informal human work and learning, and quite widely observed in nature
- The systems thinking of both formal and informal adaptive design involves turning one’s attention back and forth between conceptual and practical thinking.
- The general model of action research is also a recurrent pattern found in both other practices of informal and formal adaptive design that can be learned from.
- The general model of action research also fits the pattern of the Rosen model for how sciences and cultures learn to work with nature.

- How cultures each learn how to work with nature independently makes it hard for them to communicate
- The emerging paradigms of the systems sciences show a common pattern of exploring with their best tools to better understand reality.
- The great success of the hard sciences still leaves emergent organization in nature unexplained, while the soft sciences focus more on working nature as it is.
- Using simple models that loosely fit the shapes of natural organization has been successful for the life sciences and seems versatile as a general method.
- A practice of natural systems thinking (NST) uses a variety of simple models for focusing attention more directly on the shapes of reality.
- The "heart of pattern language" offers a versatile way to focus on high purposes for organizational change.
- The use of story arcs for growth and development offers a versatile way to develop narratives to guide the interpretation of complex change.

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