Systems-thinking + Systems-making

Joining systems thought and action

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Abstract: This paper collects recent explorations of what I call 'systems-thinking' and 'systems-making'; the first a practice of making explanatory models of complex systems, the second a practice of improvising development or change in complex systems, for making systems in the mind and in the world, respectively. As such they represent differing paradigms of both thinking and engaging with the world of complex systems. Patterns of differences and similarities that connect them are looked at while looking for how each can work better with the other. Both strategies have much in common, both tend to 1) work by accumulative nonlinear stepwise inquiry and to 2) end up in creating designs with emergent properties. They also both 3) rely on the use of natural language to communicate their specialized terms of art. Like all sciences they also both 4) rely on relating to the natural world by repeated interpreting and testing, as if in conversation, translating back and forth again and again, as depicted in the model proposed by Robert Rosen (1991). Studying those differing processes and how they work exposes some opportunity for their working more successfully apart as well as together.

KEYWORDS: systems-thinking, systems-making, learning, design, complexity, natural language, action research, pattern-language

Abstract: 191 words, References: 66 Text: 5900 words, Figures 10

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I. Systems Science Context

A. Introduction

This research paper pulls together recent threads of inquiry into the practices of 'systems-thinking' (ST) and 'systems-making' (SM), how they differ and connect. They both concern complex systems, the distinction one of emphasis, that one is primarily concerned with making mental models (as complex systems of thought) and the other primarily concerned with making complex material designs and organizations. A strong focus on one without the other would be unbalanced. A strong focus on both, alternating to work together, is more the ideal (Figure 1). One would expect creative system thinking to emerge in any of the four quadrants, and even migrating from one to another. Normal practice for either is thought of as following an exploratory path ending up converging on what is in some way holistic and practical, on in the mind the other in the world.

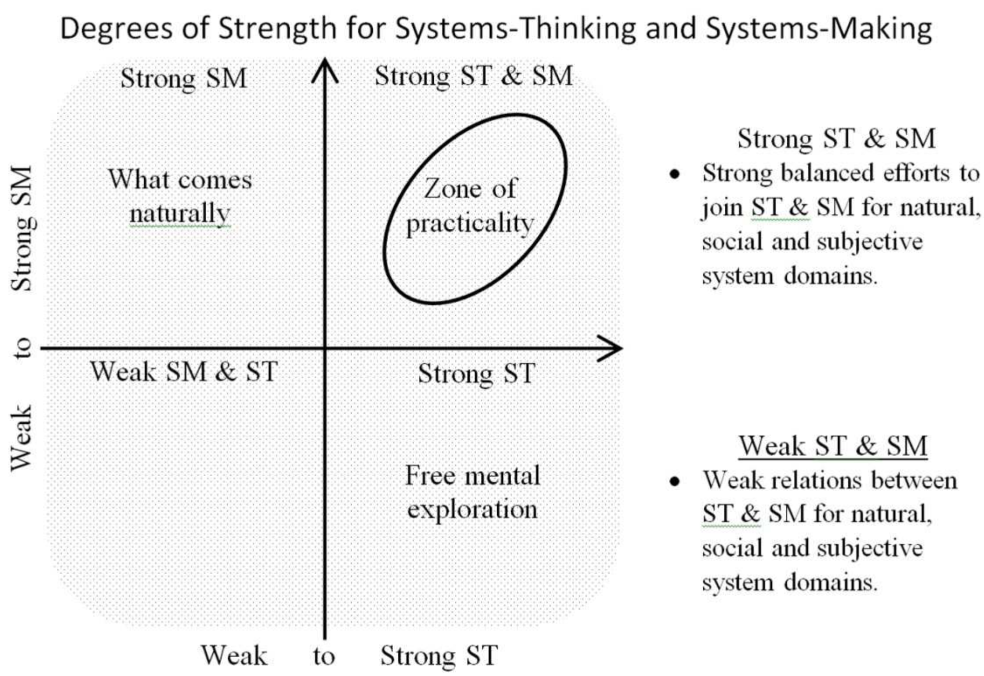

Figure 1. Strong and Weak 'Systems-Thinking' and 'Systems-Making'

My interpretation of complex systems is somewhat like that of Midgley (1992, 2016), who recognized the need for a plurality of connected paradigms, worldviews for the 1) natural world, 2) societal world, 3) subjective world and 4) their interactions. I go a bit further in extending that, to seeing a need for multiple paradigms. That is based on evidence that people culturally develop a variety of separate worldviews and readily shift from one and another, for those who know how. That's visible in how we readily switch between worldviews for differing circumstances, and for our different professional, family and personal social networks. The minimum number of four paradigms, then, seems to somewhat overlook the multiplicity of different competing paradigms people need to recognize to get along in life. In my papers on natural system pattern language (Henshaw 2015a, 2015b) I refer to this need for recognizing multiple paradigms as a 'dual-paradigm' view for conceptual and material systems. In this paper I'm positioning those issues under the dichotomy of ST and SM; ST being centered on making explanations and SM centered on making other kinds of organization.

The balance needed between SM and ST is can be through each one's coupling with the natural world, and also the natural language and words referring to things in nature. How our minds conceptually explain to ourselves will often need to ignore natural processes, and those natural processes will often need to take place developmentally on their own too. Conversely, a narrow focus on how things can materially develop can be out of touch with higher level conceptual theory, designs and goals. To keep differing paradigms in balance one's focus usually needs to go back and forth, using bridges between them, each serving as a guide for the other (see also Figures 2 & 3).

I see this work as in keeping with the developing common practice of using systems-thinking and systems-making in alternation (Ison, 2008). My thesis is that as we learn to work with complex systems, the forces we confront seem to be pushing us to clarify both systems-thinking and systems-making as separate practices, so they can better work together. To coordinate each often needs to proceed by itself. Each will also sometimes need to take the lead or hold back. Each may also sometimes need to back-track or start over in their development, with the other put on hold to end up as a real marriage of opposites that needs to be kept in balance.

The importance of each being able to remain independent comes from each being a process of organizational development, with successive additions made to fit together and connect with both the elements being built onto and those that will follow. It makes all additions into inter-connectors. A good example is in how the parts of a house need to fit together. A house is made by first removing what was there before, then digging holes for the foundations, followed by pouring or laying the foundations. That framework then allows the addition of a framework of floors and walls, to be completed by putting on the roof, allowing the installation of interiors and finishes. It's only at that point that the individualized new way of living the house was made for can begin. The historicity of each step coordinating with both the preceding and the next is all-important.

The word 'growth' also generally refers to such long processes of fitting together steps of connecting change in an accumulative sequence. Nature uses that kind of accumulative design for creating individually designed complex living systems, as well as for lots of kinds of non-living eruptions. People use it to grow their cultures and communities, their personal and professional relationships, their businesses and the world economy. We grow our ways of system-thinking too, by fitting mental images together, as we also grow our system-making by finding the right accumulation of material changes to go together too. We also use personal growth to overcome challenges in school and life, to rise to the occasion. Generally what succeeds is a chain of fitting steps that build on each other.

I mention that both to suggest the variety of kinds of growth processes that systems-thinking and systems-making might address. I also mention it to point out the shared language that may be available for discussing differing kinds seen from differing points of view. Growth of many kinds creates a home for what's inside them too. Recognizing these shared patterns for ST and SM is then a seems to offer a potential bridge between knowledge silos, even those that may have historically seemed to have little in common and unable to communicate.

B. Separate Cultures, Common Strategies

The theoretical biologist Robert Rosen pointed out various discrepancies between scientific theory and evident patterns of systems-making in nature (1991). Rosen's approach bucked the common assumption in the sciences that the laws of science are embedded in nature. His model depicts science more as a conversation with nature, the theories of science being human translations from patterns observed in nature. It makes little difference for the scientific validity of natural laws, but makes a big difference for understanding the relationships between sciences and with other ways of interpreting nature, as depicted in Figure 2.

In Figure 2, 'Scientific Cultures' and 'Maker Cultures' are depicted as in Rosen's model, turning their attention back and forth between nature and their internal processes, 'theory & implication' for the sciences, 'practice & design' for crafts. Each looks for patterns in nature their methods can reliably 'observe and encode'. Each also looks for effective ways to apply their 'implications' or 'designs' and 'decode and engage' with nature. Each kind of knowledge is fairly isolated from each other by having its own language. Each also loses different things in translating back and forth between the patterns of nature and of how they make sense of them. The implication is that each may also be finding important insights that fit within its own specialized knowledge it can't directly share with others.

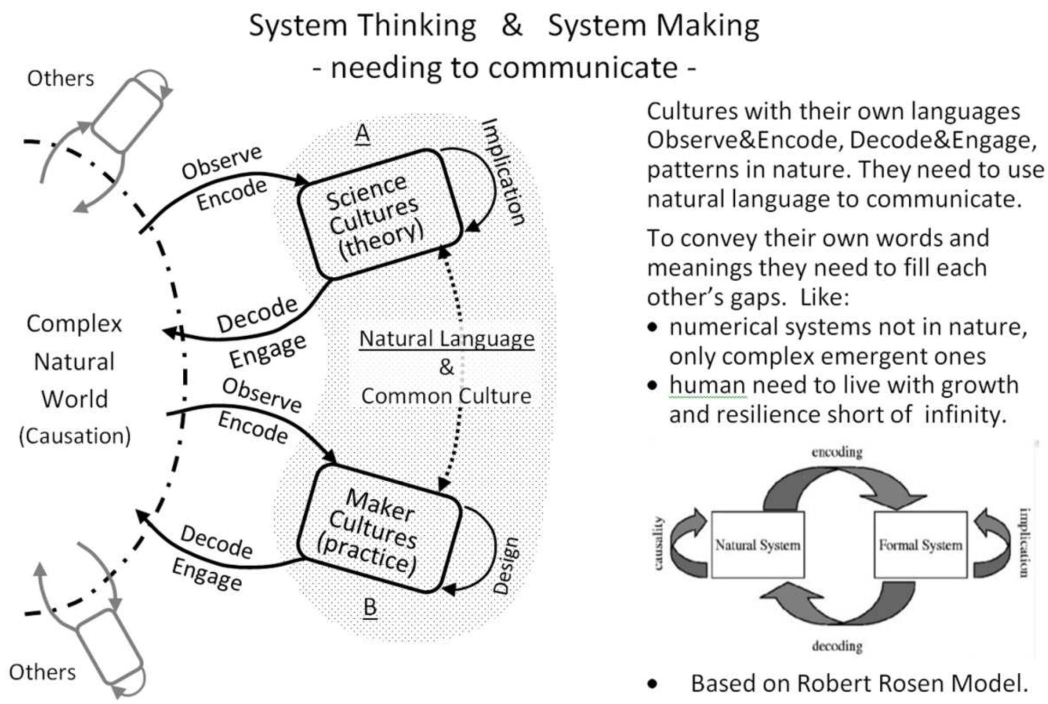

Figure 2. Systems Thinking & Systems Making only connected by common language.

T. S. Kuhn (1970) addressed part of the communication problem this creates, discussing the failure of emerging scientific paradigms to gain converts. That requires any new paradigm to gain a toe hole somewhere and then grow to replace the old paradigm; displacing rather than converting the latter's adherents. It appears the rigidity of our natural ways of thinking creates silos of culture that can't change, causing increasing friction in our world of ever faster change. As in Figure 2, differing whole cultures may develop their independent paradigms of thought side-by-side. To learn from each other it is implied that each culture might find bridges between their languages, and convey their new ideas using their shared natural language, using cultural osmosis as a means of transmission, not replacement. One place such transmission seems possible is in relation to the increasingly complex and difficult challenges of sustaining our traditional cultures in a fast changing world. Even a modest breakthrough might be tremendous.

C. Action Research Models of Structured Learning

All learning really follows a process of turning attention back and forth between subjects, not so different from the Rosen model of scientific learning. Figure 3 shows a depiction of the learning practice called 'action research' or sometimes 'action learning';

alternating periods of work and pauses for reviewing the work (Stephens et all. 2009; Flood 2010; Ison 2008; Jackson2003; Reason & Bradbury 2001; Susman & Evered 1978; Lewin 1947) . It's really a very ancient practice for designers like architects, now increasingly used for business management, software development and other design professions. The difference today is doing it much more self-consciously, in many different fields, described as a transformational source of new cultural knowledge.

What seems to be driving the interest in this form of systems-making is the need of business to have a method of systems thinking, for managing complex organizations and intense competition, giving the social sciences of the organization an important practical purpose. That business today exposes everyone to changing complex systems has the effect of making everyone a system designer. As profitable innovation in complex system learning methods creates demand around the world they can spread widely. Figure 3 shows a very conceptual diagram arranged to reflect the work of a design team that alternates between periods of work and review.

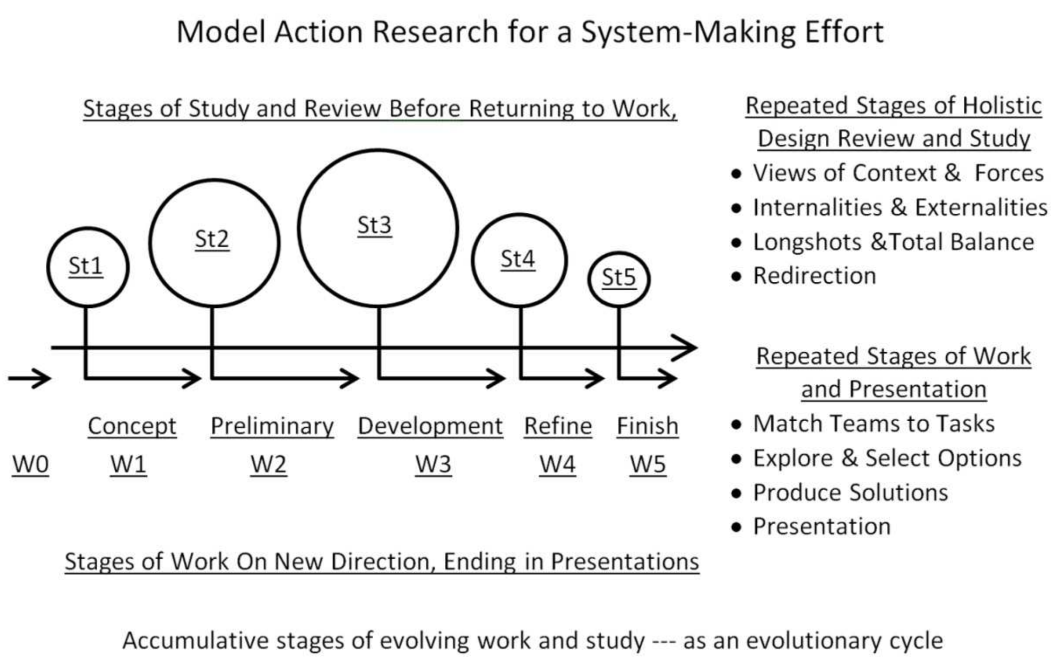

Figure 3. A general design for complex system learning.

The circles represent the pauses in the work taken reviewing the dimensions of the work, their progress, new requirements and setting new goals for the next phase of work. The arrows in the figure represent the stages of concentrated work on the new direction, ending in a presentation of all aspects to start the next stage of review. You can see that same basic pattern of alternating work and review in many kinds of familiar practices as well. It comes naturally to look up at the end of each stage of any kind of work. What has changed over time is the vastly improved knowledge and tools and viewpoints that let the practice become increasingly purposeful and sophisticated.

We can see this shape of action research as a natural strategy we commonly use for improvisational tasks like 'making lunch', exhibiting our own expertise in improvising from step to step as we go to. More sophisticated traditional sequential improvisation design are seen in how we go through school grades to get an education, with repeated periods of work and reflection. It's also present in the traditional complex business methods 'product design', involving many steps of collaboration from diverse teams of specialists all making their independent but accumulative contributions as they go. They all generally display the same characteristic succession in the scales of their steps, increasing then decreasing:

1. first proceeding from a kick off by small tentative steps,
2. then building up in a non-linear way toward taking big bold steps,
3. then to reverse direction to scale down in a similar non-linear way
4. Progressing toward smaller finishing steps that break off at completion.

That heuristic, marked by a continuity of usually non-linear rising and falling scale steps, is often recognizable by surrounding observers without direct involvement. That makes it a sign an outside observer can use to see where creative learning and development is happening nearby. That these patterns of learning come from a universal natural language of improvisation allows them possible to spread between disciplines as if by technology transfer, and facilitate the bridging of language divides as teaching new vocabulary in a common shared language of design.

Today's mainstream systems science most directly came from the abstract theoretical work the 1940's and 50's on cybernetic and information theories of Weiner (1948), Von Bertalanffy (1969) and Ashby (1956). A great variety of others took directions that built on or branched off from those founders. Economists like Ken Boulding (1956) had great influence too, bringing with them the use of economic models on which other kinds of theoretical models of complex systems were based. The origins of the modern science of complexity came later, from the discoveries by Prigogine (Nicolis & Prigogine 1967) and others in the physics of irreversible thermodynamics . A further advance came from the recognition by Georgescu-Roegen (1971) that the entropy principle of thermodynamics also applies to natural resource use. Another pivotal advance in theoretical systems science was the use of computer modeling of equations for chaotic fluctuation (Feigenbaum et all. 1982), in combination creating a new abstract theoretical world view just called 'Complexity'. (See also Henshaw (2010a) for more on how the diverse branches of the systems sciences developed and on important questions that remain unanswered).

D. Patterns of Scientific Systems-Thinking.

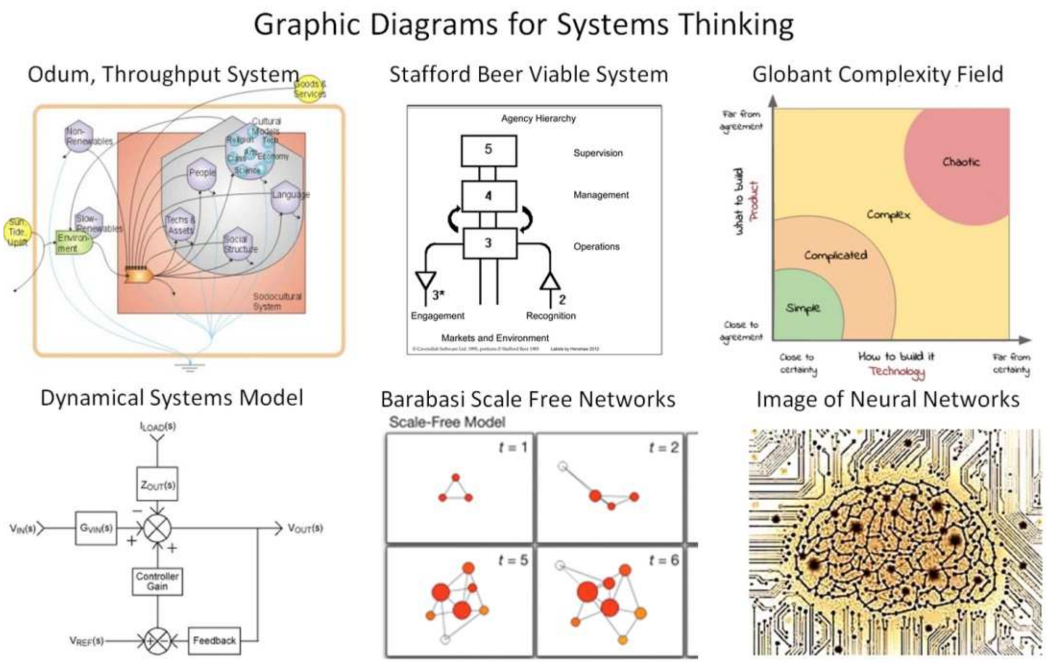

Figure 4. Systems-Thinking Concept Diagrams

More recent innovation in complex systems science has been more about computer applications with advances in modeling Complex Adaptive Systems (CAS) (Gel-Man 1993; Holland 1992; Bar-Yam 1997). Those all set the stage for the modeling 'artificial life' using cellular automata and 'artificial intelligence', for which current advances are almost too numerous to characterize (Langton 1989; Russell et all. 2003). A less technical general view of the new conception of the world of complex systems is found in Goerner's "After the Clockwork Universe" (1999). This advanced science of complexity can also be applied to business decision making as by Kurtz & Snowden's (2003) Cynefin sense making method. A Google Ngram for complexity terms (Figure 4a) shows the historic accumulative innovation in using terms for complex systems as recorded in books scanned by Google. The shapes sow various trajectories that would help one discover what is being experienced in the development of each implied field of interest.

Another root of today's complexity science is the work of earlier scientists who make quite important foundational contributions, the early economists Jevons (1872, 1885) and Keynes (1935) in particular. Their highly useful findings were not derived from abstract theory as the later complex systems fields were. Keynes' and Jevons' work was based on their own observations how economies, businesses and societies really work. It appears that some of their easily validated but neglected findings would still be of importance today, but remain neglected for not having been derived from abstract theoretical methods. Keynes, for example, noted that compound financial investment would need to end for the economy to stabilize at its limits to growth (ch 16; Keynes 1935; Boulding 1962), and Jevons observed that improving resource use efficiency generally accelerated not decelerated their rates of depletion (Jevons 1885; Polimeni 2008).

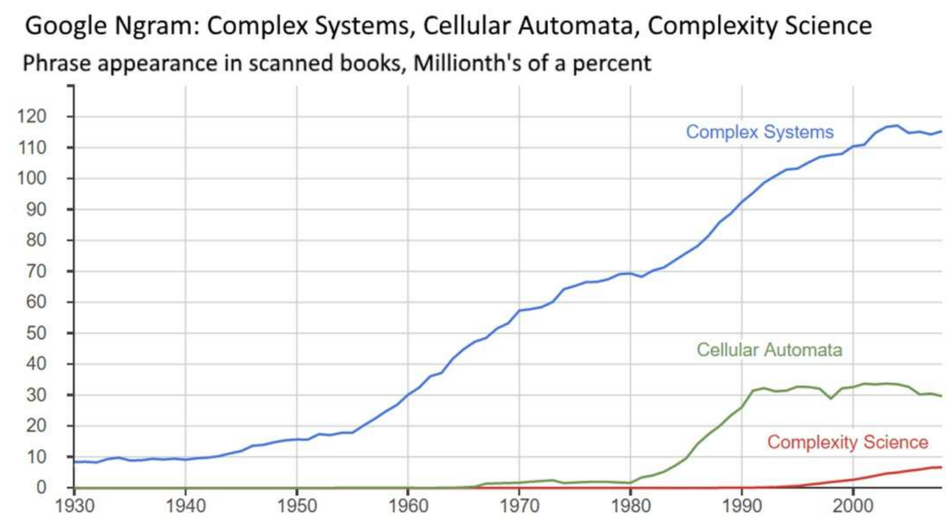

Figure 4a Complex Systems, Cellular Automata, Complexity Science Ngram

Developments in ecology also contributed a lot to advanced complex systems science, ecologists like Odum (1983) and Gunderson & Holling (2001), known to systems sciences for their innovative ways of representing natural systems with computer models. They modeled ecologies as economies of nature, adding evolutionary variables for representing ecologies as learning systems. Today the focus of interest in ecology has turned for evident reason to the complex conditions of ecological distress; understanding the complex system property called 'resilience' by Walker & Holling (2004) among many others. Others such as Ulanowitz (2009) take a more analytical approach, demonstrating an increasing pressure on ecosystems results in an inverse relationship between efficiency and resilience, with clear natural limits.

E. Patterns of Scientific System-Making

Scientific practices and theory for making and changing complex systems developed alongside the abstract sciences of complex systems theory. The use of action research as formal practice emerged in the 1940's (Lewin 1947). Roughly parallel to the abstract systems sciences, the need for business decision makers to make sense of our ever more complex world drove the development of new methods of decision making for the social and business management sciences. Making a break with the hard sciences and abstract theory, Churchman (1979) and Checkland (1981) introduced the use of natural language and use of 'soft systems methodology' for discussing organization. They were followed by numerous others focusing new theory of the learning organization and change making methodologies (Susman & Evered 1978; Reason & Bradbury 2001; Senge 2006; Jackson2003, 2007; Ison 2008; Stephens et all. 2009; Flood 2010; Checkland & Poulter 2010, 2014).

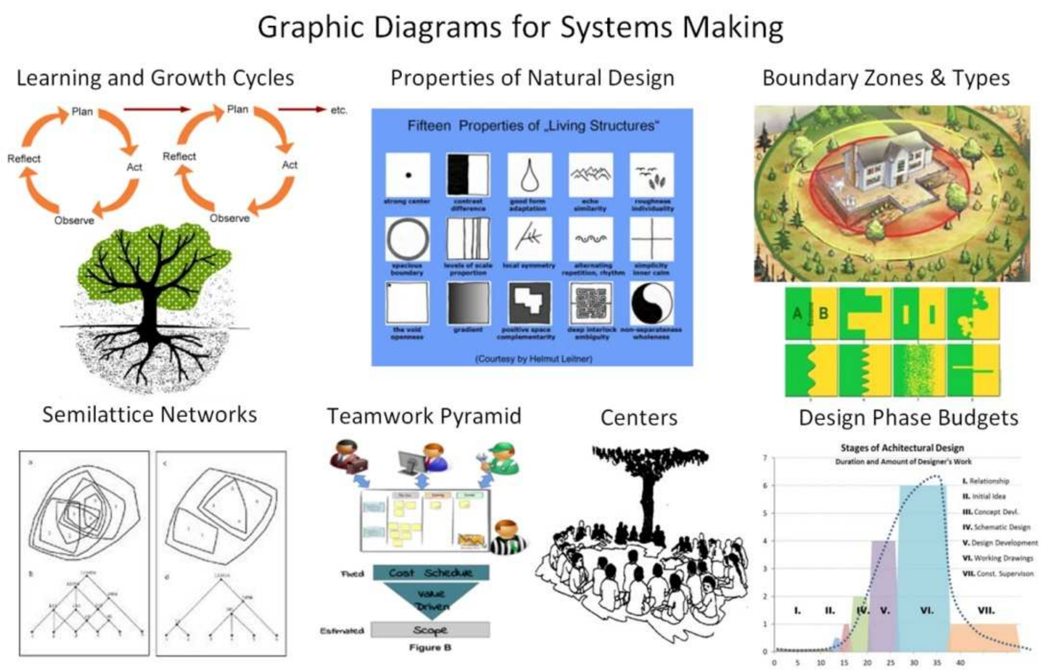

Figure 5. System Making Concept Diagrams

A modern variation worth mentioning is called the 'Agile method' and SCRUM as for highly productive teamwork (Rising, & Janoff 2000; Schwaber 1997, 2004). These movements are somewhat harder to trace than for the hard sciences for seeming natural cause. They don't get the public attention that the hard sciences have is one reason. They are also centered more on hands on methods of creative collaboration, passed down more as practices than as theories, and they are not fully recorded in research papers. Their terms of discussion are sometimes less consistent too, such as with a new term 'action learning' (McGill & Brockbank 2003) seemingly meaning the same thing as action research.

Another important innovation came from the singular contribution of the architect Christopher Alexander, and his method of holistic design called 'pattern language', implicitly a type of action-research. It was invented in the 70's as Alexander's way of making explicit the ancient methods of holistic architectural design (Alexander 1965, 1977, 1979). He defining designs in terms of unifying ideals for responding to unbalanced forces in a context. The early form of pattern language developed from

Alexander's teaching architectural theory at Berkeley and writing his first book: A Pattern Language (1977).

How holistic designs were made explicit unexpectedly also made it communicable and malleable for use by other fields. Starting in the 1980's it did indeed spread widely to other fields. It provided much of the theoretical foundation enabling the development of Wiki's and leading to Wikipedia (Gamma et all. 1995; Leitner 2016), and had particularly large impact on methods of software development, enabling the development of modern 'object oriented' software (Tidwell 1999; Rising 2000; Pugh 1991; Hillside Group 1993-2017). That ability to pass from one field to another also allowed its evolution as a method, making it potentially even more important for recording and communicating and exchanging expert knowledge of any field, helping designers of all kinds better understand the opportunities and requirements of their own designs, and more able to learn from each other's.

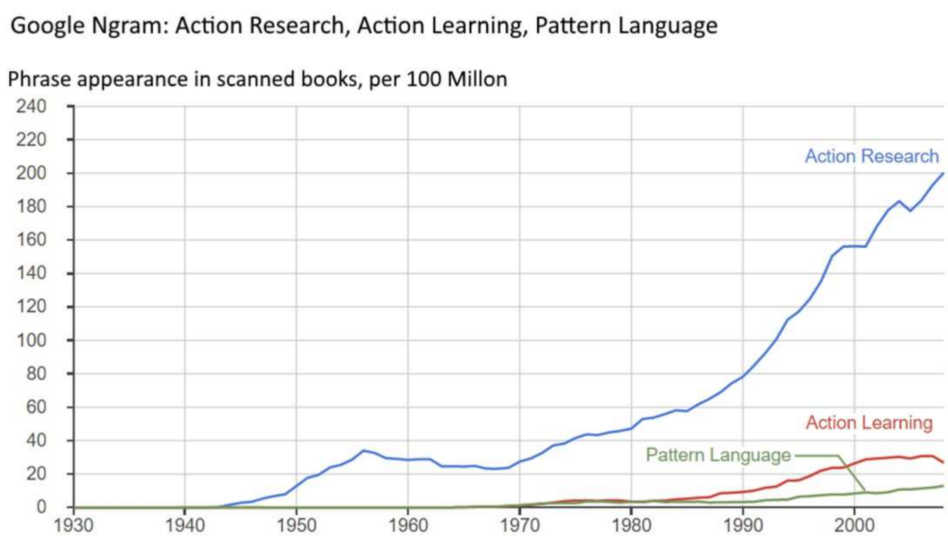

Figure 5a Ngram for Action Research & Action Learning

The Google Ngram (Figure 5a) shows the frequency of 'action research', 'action learning' and 'pattern language' in many books scanned by Google, showing the pace and timing of those emerging system-making disciplines, showing sine continuing rapid growth.

My own approach to systems science is a mixture of these methods of system-thinking and system-making, starting from my thinking about these problems as an architect, and then doing field research studying the physics of transformation in complex energy systems, a two year study of system-making processes in passive air current networks (Henshaw 1978). My method was to trace the evolution of indoor convection currents over 24 hour cycles in passive buildings, watching as their shapes and pathways evolved individually, noting how they changed for with the motion of the sun during the day. It let me closely study complexly evolving energy systems changing in form again and again over their 24 hour life cycle. They were notable for displaying predictable patterns of non-linear development in sync with their organizational changes. To make sense of them I needed a mental model of how their dynamics were linked to their phases of organizational change. That came from finding an ability to locate their system boundaries in both time and space, and correlating them with their non-linear phases in changing organization.

It's having those orthogonal views grounded in physics and infilled with long periods of close observation that led to my scientific systems-thinking about systems-making (Henshaw 1979, 1985), and resulting in a general systems theory of systems-making. That model let me interpret natural systems as a well-defined 'black box' for testing hypotheses, providing a window on how internal processes and external relationships are both separated and connected. As a body of work, my writings focus mainly on complex systems behaving as exploratory systems, either having or acting like they have actively learning parts. Those include ecologies, economies and others things that develop by innovation and growth (Henshaw 1979, 2008 2010b 2011, 2015a, 2015b, 2010c). That led to methods for recognizing more and more kinds of accumulative non-linear organizational transformations in complex systems, like both fluid flow and cultural eruptions, social community and economic community collapses, the flocking behavior of human social networks and economic markets chasing after bargains or taking flight from threats. The all exhibit a common pattern one can use to help an observer see how nature is connecting the dots.

II. Methods

A. Alexander's System-Making Template

What is most unusual about Alexander's language of holistic design is its ability to flourish while passing from one community to another. Part of what makes that possible is the structured questions one needs to ask, summarized here as structured learning template (Figure 6). It pulls a user in several holistic learning directions at once, as he described in his book, The Timeless Way of Building (Alexander 1979, Iba 2014). The template fosters a holistic approach, intended to condense the essentials of expert knowledge in recurrent circumstances. The template asks a set of challenging orthogonal questions that need to be answered together, aimed at guiding the user to satisfy the ancient ideals of architectural design.

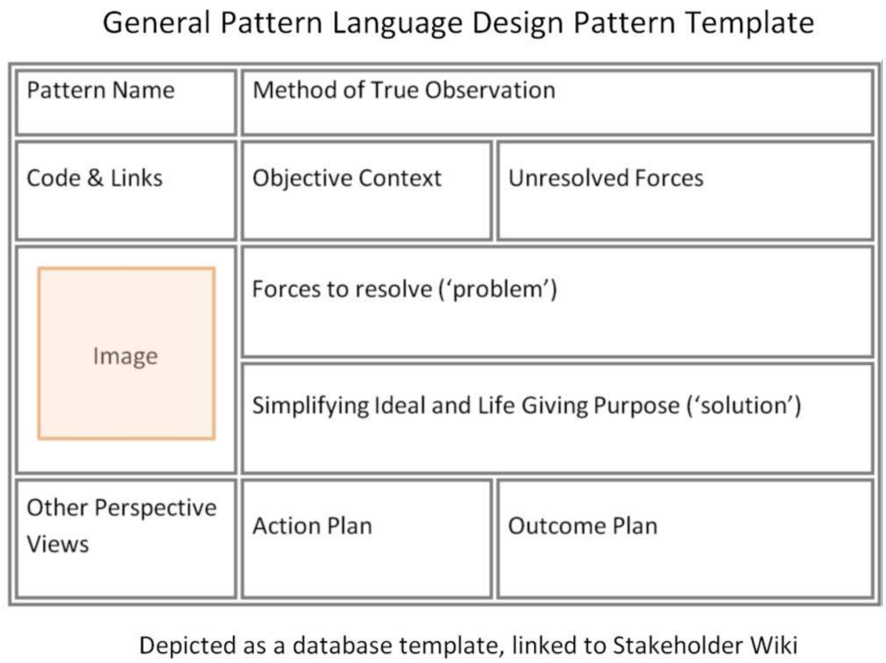

Figure 6. Template for Explicit Holistic Design Pattern Writing

The result is called a 'design pattern', for a simplifying ideal way to respond to the identified 'forces', that exhibits 'emergent properties' and creates strong 'centers' of 'living quality' (Alexander 1979). Speaking of its use for software development, Jennifer Tidwell (1999) touches on the heart of why this method makes that possible:

> *"They are not abstract principles that require you to rediscover how to apply them successfully, nor are they overly specific to one particular situation or culture. Instead, they are somewhere in-between: a pattern describes possible good solutions to a common design problem within a certain context, by describing the invariant qualities of all those solutions."*

My recent papers extend the pattern language approach to understanding this kind of pattern in naturally occurring system designs (Henshaw 2015a 2015b), and also contain a variety of references and supplemental resources.

A 'home' is such a very common almost magical solution for a recurrent problem, 'a simplifying ideal' responding providing a private space to live the way a family or culture would like to arrange for themselves, an enclosure, also having openings for access as desired with the outside world. It's the simple way it allows its inhabitants to arrange their own way of living that balances the forces of living in a complex world. For another example, 'a currency' is another ideal expert solution, also fraught with sometimes great risk for those who don't understand what it can and cannot do.

Money is a common token of value that each holder assigns their own value to in trade with others, so normally every exchange is profitable to both, a marvelous solution. These emergent properties of designs producing almost magical results is what them so important to study and really understand. If you make a home with only the front wall, or without openings, it doesn't work. If you make a currency that promises limitless growth in value, Ponzi scheme or investors bubble, everyone becomes is a loser. So the systems-thinking used for Alexander's technique of systems-making is recognizing these 'neat packages' of design elements with very powerful positive and/or negative emergent effects.

Learning to fill a blank template is what guides a designer to study their contexts for unresolved forces to then search for simplifying ideal ways of resolving them. As with any design process you don't automatically know what design elements you'll need to weave together, and are looking for solutions with truly lasting and reusable value. At first a blank template engages you in an open ended task of 'problem finding' by setting up a practical framework to fill in for idealistic 'solution finding'. The work goes back and forth between study of the environment and developing the template, to end in a design how to engage with the environment in a satisfying way. At each stage of review as the design pattern is developed you reopen all the questions to see how they might be enlarged upon, asking pattern breaking questions to prompt a wide exploration of fresh perspecitives, such as;

1. for the internal and external relationships of systems studied,
2. for the independence and connections of the parts,
3. for searching their natural world, societal and subjective relationships.
4. for both the subjects as they exist and as they are interpreted.

Perhaps as great a value as the method itself is the suggestion that designers have apparently been doing this kind of thinking since the dawn of civilization, in the past only passing it down non-verbally. How this kind of design template is developed, and then how it might be used, might follow the action-research model is as depicted in Figure 3, in each phase going back and for the between ST and SM as the design and the implementation develop. Seeking simplifying balance of the forces and life-giving qualities as explicit ideals, the structured learning becomes a scientific method of holistic design.

B. ST & SM Guides I – Common Design Tasks

Figure 7 depicts two very general systems-thinking guides for system-making. The first guide (7.1) symbolizes the rising and then falling complexity of efforts for starting and completing any task, as an 'inside view' of it. The second (7.2) shows the accelerating and decelerating accumulation of energy and other resource uses in the process. Both have beginning (A) and ending (B) periods for the respective 'build-up' and 'build-down' phases. To use these guides you just need to think through the kinds of decision making involved in guiding familiar projects from beginning to end, think through their familiar build-up and build-down phases.

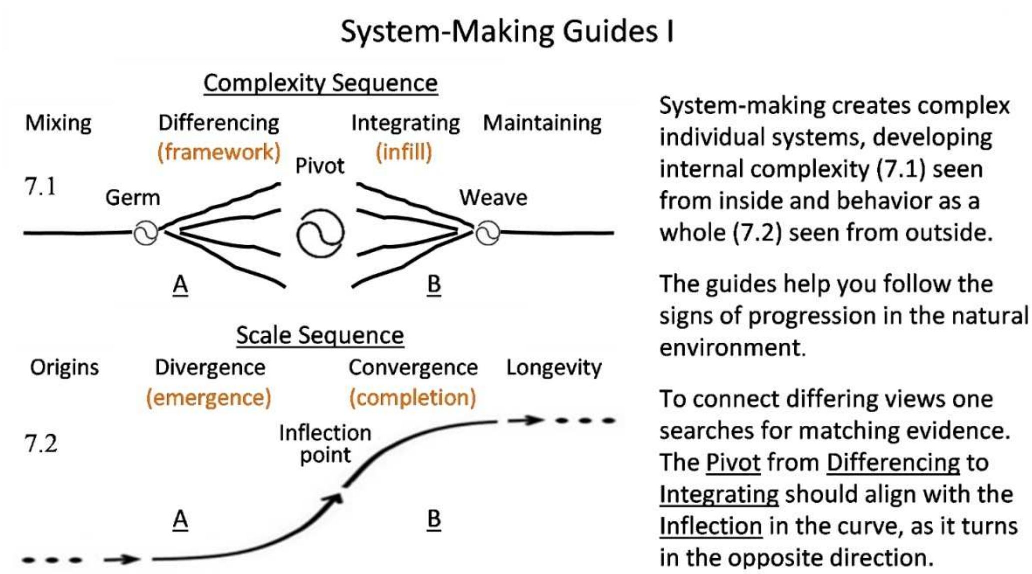

Figure 7. Process Diagrams for System-Making

Take the improvisational task of 'making lunch' for example. It might start from opening the fridge to get out the main ingredients, collecting the needed dishes and utensils, and thinking through the appetites that need to be satisfied. It's generally a design task that starts with an idea to then proceeds with bringing together framework elements to be filled in with the details of the end product. As you are making lunch watch closely how you first set things up and then finish them up in creating the finished product. All along the way your attention turns back and forth between the concept developing in your mind and the process developing on the kitchen counter. That initial stage sets up the framework for the work, getting everything ready to combine. That framework stage *differentiates* the ingredients by task, expanding the complexity of the work by increasing steps at first, up to the 'pivot' toward reducing the scale and complexity of the process again, as you fill in the framework with successively smaller details. As that nears completion the final touches added are to 'weave' the product into the environment in which it needs to fit, to achieve a satisfying balance and full service in the end.

This normal way people go about improvising familiar design tasks, going back and forth between ST for the intent and SM for putting the pieces together, is the normal natural stepwise practice we use for our interactive learning and doing. That intuitive way of doing things is what the more formal 'action research' methods and projects are based on. Generally formal plans would include all the parts of (7.1 & 7.2) as the most general case. Generally an outside observer will be less able to follow the expanding and contracting complexity of the internal process (7.1). Observers will be more aware of the rising and falling scale of change and its constraints (7.2), than the people absorbed in the complexity of the details. The shift in perspectives, from one to the other, goes with a difference in exposure, each view allowing different things to be seen more clearly and others hidden from it. The combination is not unlike viewing a house from the view of a roof plan and a front elevation, and needing to discover they are two different *orthogonal* views of the same thing.

Other examples that can be studied this way include 1) designing a home 2) going through a grade level in school and 3) how we respond to emergencies. Many natural processes follow the same pattern too, though our terminology for them may differ, such as 4) biological reproduction from fertilization to birth, or from birth to maturity in two stages and 5) the growth of civilizations from their early flowering, 'renaissance periods', to their 'classical periods' of stable refinement. What the various whole system diagrams do is provide easy ways to arrange the whole narratives of complex accumulative design stages, 1) Comparing the 'inside view' (7.1) and 'outside view' (7.2) as proceeding in a familiar ways, and 2) comparing beginning (A) and ending (B) periods with their associated stepwise 'build-up' and 'build-down' processes.

The beginning and ending stages, (A) and (B), of increasing and decreasing complexity (7.1) generally do correspond to the respective stages (A) and (B) of accelerating and decelerating increases in scale (7.2). The stages of each kind of development may vary considerably of course, and given names associated with the observer's view. Seeing evidence from one view will often help you find corresponding evidence in the other, like learning to read overhead and front elevation views of the same whole building. So, very importantly, one can quite often confirm a finding of one kind with evidence of the other kind.

All three of the major turning points in an accumulating complexity (7.1), the 'germ', 'pivot' and 'weave' as points of change. They mark changes in the system's way of changing, occurring at times and in ways when very little may seem to be changing. Looking from an outside view (7.2), at a trace of the changing scale of accumulating change, offers little hint of internal complexities that are causing the shifts in direction.

1) At the major inflection point in the middle, where the whole process turns from expanding to filling in the framework of the design, the outside view shows no evidence of change at all.

2) For 'making lunch' the small final touches of making a nice presentation of the meal and putting the food into the lunch box or on the table generally make big differences in enjoyment.
3) Without a method that prompts you to study the plurality of world views available one might well entirely overlook that meals are social ceremonies as well as plates of food, even when prepared only for one's self. Those kinds of greater purposes are often present in the initiating 'germ' of any process if you look just a little closer.

C. ST & SM Guide II – System in Environment

Our systems-thinking about the systems-making of complex systems can also portray the subject as located in its environment (Figure 8): as an organism, a project or a person's or a culture's life. The build-up stage of the system framework (A) is shown as a block of self-investment, with inputs and outputs driving its growth(8.1)

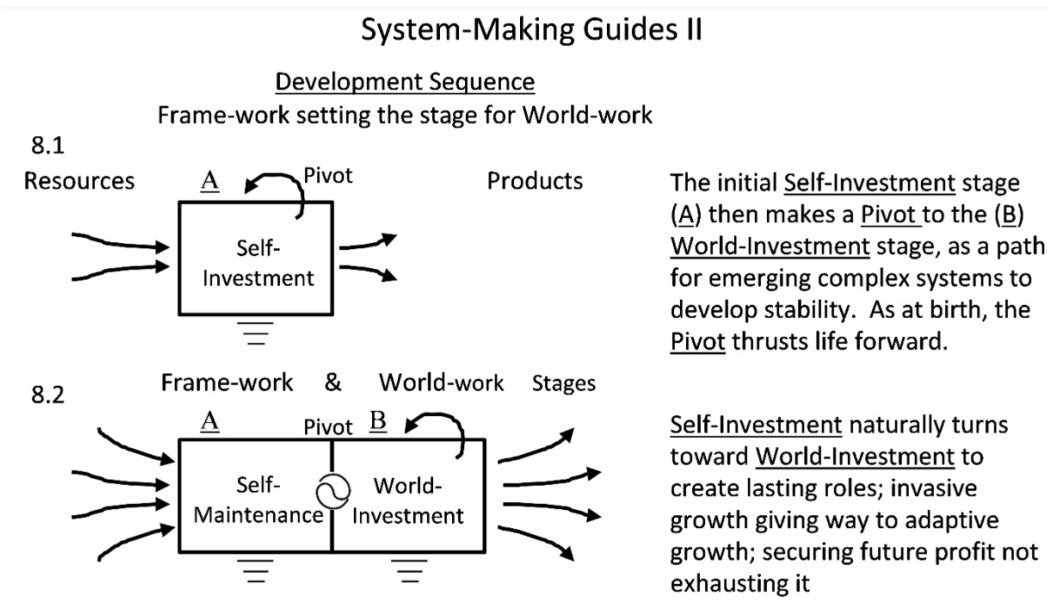

Figure 8. Organization Phase Diagrams for Systems Making

With the 'pivot' from 'Self Investment' for making the system's emerging frameworks (8.1 to 8.2) a second block is shown being added for filling in the frameworks of A and B for 'Self-Maintenance" and 'World-Investment'. This is a simplified the general systdms growth model as for building a business that doesn't see its purpose as taking over its world but becoming a reliable partner in it. The complex system referred to could also be that of a culture (considered as an organism) or a person's life's work, for having these same interrelated functions. For a family business the 'pivot' is usually at that point is when it has adequately established itself to be secure, allowing it to turn its attention to living well instead of putting every resource and effort into expanding the business. Disposable income is are then available for their life savings for the future, serving their society and enjoyment, for example.

The validity of this kind of research is as for forensics, proven by the usefulness of what you find. As life-cycle patterns such as these become familiar the main test of validity will be the feedback of accumulative useful learning itself; the more you learn the more you find. Using the structured action research (like Figure 3) with a template for repeatedly exploring the world of options as (like Figure 6) as you proceed, is designed by intent to be self-critical and objective. It does not keep you from overlooking things but leads you on a path of reliable connections. So a well-constructed action research tends to naturally produce satisfying results as its positive feedback for the direction taken. It's no guarantee the whole approach isn't unbalanced, though, and independent methods of evaluation are smart to include too.

One broad method of evaluating systemic interventions is given by Midgley (2007). It can be difficult to know what criteria to use for measuring the success of multi-stakeholder action-research projects in particular. The differing worldviews of the stakeholders often don't communicate well, and the criteria for evaluation may come at the end and be significantly biased. That dilemma is somewhat balanced by just broadening the view. An outsider to the process can ask more general questions, Midgley suggests, for assessing the overall fitness of the project for the circumstance on three dimensions.

The basic goal is to assess the project as a whole for fitness and balance of its own parts, asking whether it was well suited for 1) the circumstance, 2) for the abilities of the team involved, and also 3) for the purpose intended, a kind of 'systems-thinking' about a process of 'systems-making'. Additional general fitness indicators could also be added as well, such as required for Alexander's explicit criteria for holistic designs, like having 'emergent properties' and producing 'living quality' in the result. The value of this approach is partly that of getting to judge the project using criteria different from those used in doing it, i.e. and alternate point of view. It directly addresses a common problem with action research efforts, that of doing one thing quite well and others somewhat poorly, so falling short addressing the subject as a whole.

III. Conclusion

In this review we have focused on 'systems-thinking' and 'systems-making' as 1) creating complex conceptual systems in the mind as opposed to 2) making complex material systems in the world, that in practice. We have surveyed many of their differences in subject matter and methods that distinguish them as separate kinds of activities and with different long histories of development in the sciences and culture.

That led us to exploring various methods for working together to combine their strongest differences to mutual advantage. We've seen that ST can apply to making better design templates for guiding SM, as well as better performance criteria for evaluating SM, and how SM. We've shown how SM can make ST relevant to the environmental contexts that ST can only refer to in abstraction. The sorting out of these differences and new ways of connecting them will hopefully be found to have emergent values for the systems sciences and for our common challenge to learn how to work with nature.

IV. Acknowledgements

Thanks go to Helmut Leitner and Gerald Midgley for useful suggestions and for the freedom I've had to do the work. Thanks too, goes to Kurt Richardson for his long support.

V. Bio

Jessie. Henshaw's innovative systems science goes back to the 1970's. Her degrees are in physics and architecture. Having been taught to learn from observation let her notice the strong similarity of life-cycle patterns of natural and human designs complex accumulative design of both natural and human systems sources. Her initial field research on natural system energy use was of how convection develops and subsides over 24 hour periods within houses. The main finding was the particularly clear connection of stages of non-linear energy use with non-linear progressions in emerging system-making in the forms of air currents and their pathways. From that her body of physics and natural system design research developed for recognizing and narrating observed non-liner dynamics and emerging phases of organizational change for human and natural systems. Jessie presently lives in New York City. She has a B.S in physics from St. Lawrence University, post-graduate study in mathematics and architecture from Stony Brook and then Columbia Univ., a masters in environmental design from the Univ. of Pennsylvania, and her extensive body of research. She does consulting, research and writing as *HDS natural systems design science.*

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