InSites
A Support Network for Educational Change

Using Complexity Science Concepts When Designing System Interventions and Evaluations

Beverly Parsons
InSites (www.insites.org)

The ideas from complexity sciences and their application to evaluation are discussed in more detail in two documents available on the W.K. Kellogg Foundation (WKKF) website. The names of the documents are (a) An Overview: Designing Initiative Evaluation and (b) Designing Initiative Evaluation: A Systems-oriented Framework for Evaluating Social Change Efforts. Go to http://www.wkkf.org and enter the name of the document in the search box to find them in the list of WKKF publications.

Complex Social Systems

Complex social systems are composed of massively entangled formal and informal organizations and networks. They may be an interconnected web of hierarchical, bureaucratic organizations, networks of small formal and informal groups, communities, family systems, and more.

Deeper understanding of these complex systems comes through viewing them as having multiple dynamics. An understanding of system dynamics provides ways to observe, live within, and influence social systems. System dynamics can be described as three types—organized, adaptive (self-organizing), and unorganized.

A useful way to think about the relationship of these multiple dynamics within complex social systems builds on the work of Ralph Stacey[1] who views the degree of (a) agreement and (b) certainty in a social system as the basis for differentiating system dynamics. "Agreement" refers to the degree of accord among, for example, those in a group, team, organization, or community about their priorities and the activities they engage in. "Certainty" refers to how predictably cause-and-effect relationships among actions, conditions, and consequences can be anticipated. (See Figure 1.[2])

1 *Stacey, R. (1996). Strategic management and organisational dynamics. 2nd edition. London: Pitman Publishing.*
2 *This figure is based on the work of the following two sources as well as Stacey (referenced earlier); Zimmerman, B., C. Lindberg, & P. Plsek (2001). Edgeware: Insights from complexity science for health-care leaders. Irving, TX: VHA, Inc. and Human Systems Dynamics Institute (www.hsdinstitute.org).*

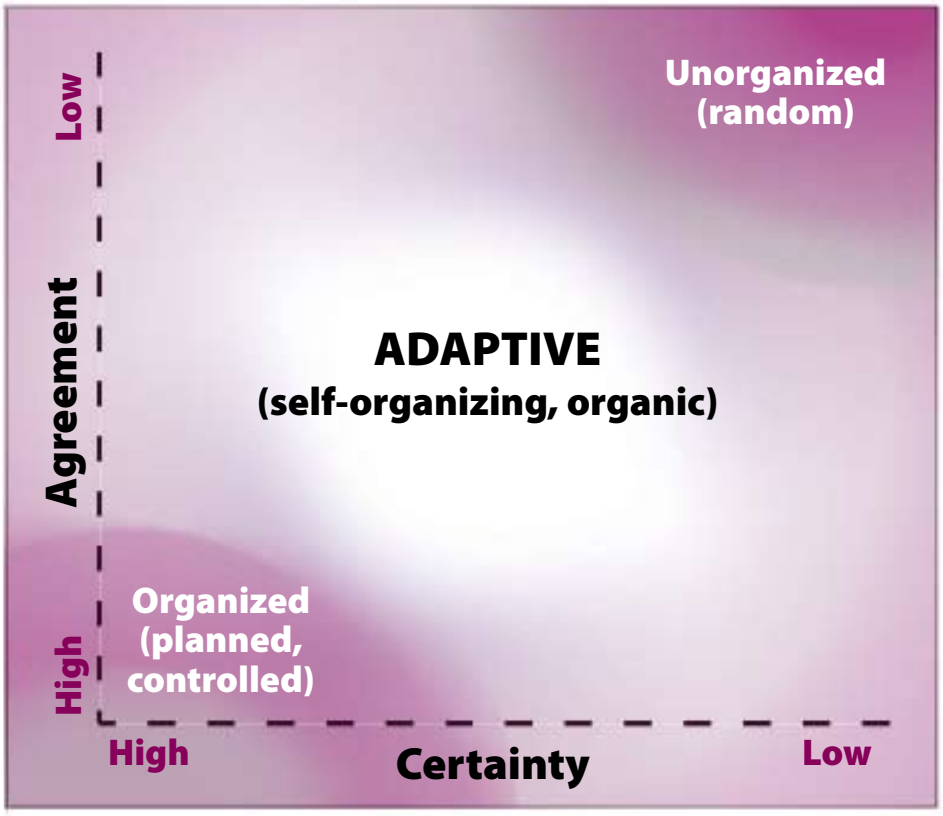

Figure 1. System Dynamics related to Certainty and Agreement

Organized System Dynamics

Where the levels of certainty and agreement are high (lower left of the diagram), one finds **stable, organized, predictable system dynamics**. Traditional hierarchical organizations and assembly lines are largely designed on the assumptions of this type of system dynamic. They are based on structured roles, planning, and control.

Organizations that emphasize this dynamic are often nested systems such as levels of government, in which the local level is nested within the state level which is within the federal level. However, this dynamic may be present in a small system. For example, training sessions are often designed around this dynamic. Instructional processes are carefully designed to lead to planned student outcomes. The design of the instructional processes is based on research evidence and the learning outcomes are measurable.

Research and evaluation methods that assume linear (or simple non-linear) cause-and-effect relationships are designed with an assumption of organized dynamics.

Unorganized System Dynamics

At the other end of the spectrum shown in the diagram, where systems exhibit both low certainty and low agreement, one finds a **random, unorganized dynamic** such as one might find at the moment of a natural disaster. Systems have essentially disintegrated. Actions are unpredictable and random. Within complex social systems, many events and actions can appear to be random. We cannot see any patterns or connections between them and other events or actions.

Research and evaluation methods that rely on probabilistic statistics (e.g., correlations between a dependent and independent variable) assume that what is not predictable by the cause-and-effect model of the method is unorganized and random.

Adaptive System Dynamics

Between these two ends of the spectrum is a special dynamic. The system is far from the equilibrium of either an organized state or the disintegration of an unorganized state. **It is a complex adaptive system (CAS) where agents self-organize.** Since it is the way plants and many animals organize, it is sometimes referred to as **organic organizing**. The core idea is this: *In complex adaptive systems, many semi-independent and diverse agents, who are free to act in unpredictable ways, continually interact with each other. They are adapting to each other and the environment as a whole.* They can create influential system-wide patterns. They are not necessarily moving toward stability and tend not to be controllable although they can be influenced.

Interconnections of System Dynamics

In the figure and in our explanation above, we have described the dynamics as if they are separate. However, two points are important to realize:

1. The three types of system dynamics are entangled in social systems. To gain understanding of a complex system, we may selectively look at dynamics. It is as if we had glasses that filter out certain dynamics. When we view the landscape of systems, the glasses do not change the landscape itself but allow us to experience the landscape in a different way.

2. The three types of dynamics can be thought of as different phases and types of energy that can transform from one to another. It is much like water being able to be a solid, liquid, or gas. The action around the boundaries of these transitions is important. Considerable movement is occurring and may be especially influential in systems change.

Complex Adaptive Systems and Adaptive (Self-Organizing) Dynamics

A wealth of tools and methods exist for understanding and influencing the planned/organized dynamics. These tools and methods, based on linear and/or simple non-linear predictions of cause and effect, include strategic planning, setting specific outcomes, and using research methods such as randomized controlled trials (RCT). Because the language and concepts of organized systems are well known, we do not address them in this paper. Instead, we want to elaborate on concepts about complex adaptive systems and the nature of adaptive dynamics. This is the place where new vocabulary and concepts can be helpful in understanding complex systems and their dynamics.

The complexity sciences have their beginnings centuries ago, but the ideas started to receive serious attention in the scientific community in about the 1980s. Thus, the understanding and applications of the concepts are still in their early stages of development.

The concepts below originate in the physical and biological sciences and have mathematical underpinnings. In the descriptions below, we have tried to strike a balance between retaining the language of these fields and describing the concepts in terms more commonly used in the social sciences.

Although the idea of multiple dynamics within social systems is often quickly understood at an intuitive level, the terms can be difficult to understand at first. Once grasped, however, the concepts provide a powerful set of tools for understanding and influencing organizations and networks. The tools provide the basis for taking action, undertaking research, and evaluating change within these entangled systems.

Theories about complex adaptive systems take the position that there is a powerful and important dynamic in systems—self-organization—that can be understood and leveraged for change. To leverage the power of self-organizing, we need a language and set of concepts to guide our actions, research, communications, and evaluation

processes/methods. The list here is basically a vocabulary and concept list.

1. **Self-organizing/adaptive/organic:** In a self-organizing (adaptive/organic) dynamic, many semi-independent and diverse agents, who are free to act in unpredictable ways, continually interact with each other. Although these agents may be unaware that they are part of a larger whole, they are moving and adjusting to other agents and to the environment as a whole. Human networks such as the Internet are examples of self-organizing/organic dynamics where no leader is in control. This is also the way ants organize, through signals from the chemical compounds of pheromones secreted by other ants.

2. **Sensitivity to initial conditions:** In complex systems, very small differences in initial conditions can have a disproportionately large impact on future events. Because of such sensitivity (and other factors), outcomes at specific times or locations within self-organizing systems are unpredictable.

3. **Emergence**: New, unexpected structures, patterns, properties, or processes emerge in self-organizing/adaptive systems. These are higher-level phenomena that unexpectedly come about from the actions of a multiplicity of small occurrences. The small occurrences were not planned to create the new order. The emergence of the new is not controlled by a single entity, but results from semi-independent interactions of many agents.

4. **Macro patterns:** When a relatively large group of semi-autonomous agents are self-organizing, they frequently create macro patterns (patterns of the whole group). These patterns are defined by underlying "simple rules." The agents are not necessarily conscious of the underlying rules of behavior and no one agent controls the behaviors.

5. **Feedback:** Agents in self-organizing dynamics are "learning" from one another and the context through feedback. As they get signals from other agents, they modify their behavior. In order to adjust the pattern over time and space, it is critical to link feedback to the underlying simple rules that create the pattern of the whole. Humans, as conscious beings, have even more complex feedback mechanisms that shape their behavior patterns.

6. **Co-evolution:** Co-evolution refers to the interdependent evolution of two or more systems within a larger ecological system. Cooperation, competition, and interdependence in relation to the same limited resources create feedback among the systems. This is another example of how agents adjust through feedback. For example, a service provider system and the community can be thought of as co-evolving when there is mutual feedback. Each system is shaping the other and shifting patterns of each system in an interdependent way.

7. **Pattern formation and points of influence:** Dynamic patterns arise among agents and between agents and their environments over time and location as *relationships, boundaries, and differences in energy* occur. Although the patterns are too complex to be controlled, it is possible to influence patterns by intentionally adjusting relationships, boundaries, and/or energy differences.

Implications for System Interventions and Evaluations

The above concepts lead to rethinking how to influence complex systems.

1. **Small differences can create large effects.** If leverage points are found that shift patterns in self-organizing dynamics, small differences can lead to large and multiple effects. Any intervention in the system can be influential.

2. **The past influences but does not predict the future.** Social systems are dynamical, that is, they are continually changing in irregular ways. The more a social system is dominated by self-organizing and unorganized dynamics, the less the past predicts the future. At the same time, such a situation may provide more opportunities to shape patterns through small well-chosen actions.

3. **Many points of influence exist.** A social system is a complex mix of organized, self-organizing, and unorganized dynamics. Recognizing the characteristics of each expands one's range of options for influencing systems. To achieve social outcomes, notice the existence of each of the dynamics in the situation, pay careful attention to the differences among them, and consider how to leverage each to affect the situation.

4. **Boundaries, differences, and relationships are levers of influence toward a purpose.** When analyzing a situation to understand possible points of influence, think in terms of boundaries, differences in levels of energy, and relationships (interconnections and exchanges). Consider how one or more can be adjusted or influenced to move toward or maintain a purpose-based direction.

5. **Simple rules underlie patterns.** Synthesize what is learned about boundaries, relationships, and differences as levers of influence toward a purpose. When these are synthesized, simple rules that govern deep processes in the particular situation start to become evident. These can be articulated as flexible, adaptable rules of action (simple rules) that people throughout the system can use to guide their actions in multiple situations to maintain or intentionally change the deep patterns.

6. **Pattern-based feedback and action are iterative.** Because the consequences of any action in a complex system are seldom predictable, it is important to identify points of influence that tap into deep structures/processes that underlie the dynamics of a system. To shift the patterns of systems, it is essential to repeatedly (iteratively) apply feedback related to those points of influence. Because this kind of feedback links to the simple rules underlying the deep structure, it can help shape patterns.

7. **Tensions are not resolved.** When self-organizing is a strong dynamic, expect to hold differences in tension rather than resolving them. Tensions such as conflict and cooperation, dependence and interdependence, and dominance and subordination continually coexist.

8. **Patterns are outcomes.** Self-organizing/adaptive systems are not expected to produce a specific outcome at a specific time. Think instead of the desired outcomes in self-organizing dynamics as patterns of behavior that modulate and tend to stay within a particular range of behavior. However, sensitivity to minor changes and the possibility of emergence of new patterns, structures, and properties is ever present.

Acknowledgements

This document is part of a series of tools from InSites. It was prepared in part with funding through InSites' contract with the Center for the Study of Social Policy to conduct an evaluation of the Quality Improvement Center for Early Childhood (QIC-EC). Marah Moore, Patricia Jessup, Mallary Tytel, and Rosemary Reinhart provided input. The document was designed by Kathy Wyckoff.

The information and opinions provided herein are the sole responsibility of the authors and do not represent agreement or positions of the funding agents.

References and Further Reading

The following references are among the many that have influenced this document. They are recommended to those interested in further reading on this topic.

Barabasi, A. (2003). *Linked: How everything is connected to everything else and what it means for business, science, and everyday life*. New York: Penguin.

Eoyang, G. (1997). *Coping with chaos: Seven simple tools.* Circle Pines, MN: Lagumo.

Johnson, S. (2001). *Emergence: The connected lives of ants, brains, cities and software.* New York: Penguin Books.

Meadows, D. (2008). *Thinking in systems.* White River Junction, VT: Chelsea Green Publishing Company.

Midgley, G. (2003). *Systems thinking.* Thousand Oaks, CA: Sage.

Miller, J & S. Page (2007). *Complex adaptive systems: An introduction to computational models of social life.* Princeton, NJ: Princeton University Press.

Olson, E. & G. H. Eoyang. (2001). *Facilitating organization change: Lessons from complexity science.* San Francisco: Jossey-Bass/Pfeiffer.

Parsons, B. (1998). *Using a systems change approach to building communities. In The policymakers' program: The first five years: Implementation tools. Volume II.* St. Louis, MO: The Danforth Foundation.

Parsons, B. (2007). "The state of methods and tools for social systems change." *American Journal of Community Psychology*. 39(3), 405-409. New York: SpringerLink.

Parsons, B. & P. Jessup. (2009). *Questions that matter: A tool for working in complex situations.* Ft. Collins, CO: InSites.

Patton, M. (2010). *Developmental evaluation: Applying complexity concepts to enhance innovation and use.* New York: Guilford Press.

Ramage, Magnus & K. Shipp. (2009). *Systems thinkers.* London, UK: Springer.

Rogers, E. (2003). *Diffusion of innovations. (5th ed.)* New York: Free Press.

Senge, Peter M. (1990). *The fifth discipline: The art and practice of the Learning Organization.* New York, NY: Currency Doubleday.

Snowden, David J., and M. E. Boone. (2007). "A leader's framework for decision making." *Harvard Business Review*, November, pp. 1-9.

Stacey, R. (1996). *Strategic management and organisational dynamics. 2nd edition*. London: Pitman Publishing.

Stacey, R. (2007). *Strategic management and organisational dynamics. 5th edition.* London: Pearson Education.

W.K. Kellogg Foundation. (2007). *Designing initiative evaluation: A systems-oriented framework for evaluating social change efforts.* Battle Creek, MI: W.K. Kellogg Foundation.

Williams, B. and Imam, I. (ed.). (2007). *Systems concepts in evaluation: An expert anthology. I*nverness, CA: EdgePress.

Zimmerman, B., Lindberg, C., and P. Plsek. (2001). *Edgeware: Insights from complexity science for health care leaders.* Irving, TX: VHA, Inc.