SYSTEMS RESEARCH: HOW DO WE DISCOVER WHAT WE NEED TO KNOW, ACCORDING TO WHOM, AND FOR WHAT PURPOSE?

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INTRODUCTION

The idea of the Anthropocene, an era in which human presence and behavior have become the most important factors of change on the Earth, increases long-standing questions about research. How do we discover what we need to know according to whom and for what purpose? The goal of our presentation is to introduce some consideration for a systemic approach to research and to provide stepping stones toward a path forward.

At a time in which the most troubling problems are often labeled as *systemic* (e.g. global financial relationships, environmental concerns, weather-related catastrophes, etc.) there is a need to reevaluate the ways in which we learn about and model the worlds in which we live. Increasingly, thought leaders recognize that critical thinking and positivistic approaches, while valuable, are insufficient to comprehensively and constructively address the most pressing issues of our time. Our ability to capture the dynamic nature of systems remains limited, though. As the urgency of issues related to governing the Anthropocene becomes more prevalent, Systems Research and application in Systems Practice is gaining increased attention across and beyond the Systems Sciences.

OVERVIEW OF THE EVOLUTION OF THE SYSTEMS SCIENCES

Most research is still judged by the tenants of traditional science, which historically presumed that we could observe and measure, and ideally conduct controlled experiments on, the phenomena that we chose to study. Knowledge gained should be verifiable by other researchers, implying that properties or behaviors in question should remain consistent across time and space.

Understanding systems as patterns of organization, most do remain relatively stable. In essence, the world that we know looks much the same each morning as it did the night before. Change happens, but in predictable ways.

Traditional research approaches worked well for discovering the most fundamental principles of the physical world (matter and energy, light, etc.). Those principles continue to hold true, though not as absolutely or eternally as was believed a hundred years ago.

What we now know as systems science (or various other terms) is often traced to two related sources. One is the work of Ludwig von Bertanlanffy in biology, and the other to what became known as cybernetics, focused on information and communication. Bertalanffy's most notable contribution was the theory of *open systems* as a way to explain the principles of living organisms as distinct from their physical makeup. (The properties of the materials did not cause organisms to be alive.) Cybernetics contributed to early theories of communication and cognition, and their dynamic interactions.

Philosophically, the theory of open systems challenged what had become a mechanistic view of the universe, based on the reduction of all reality to particle physics. Second-order cybernetics helped to challenge the concept of neutral observation by scientists and other researchers. In effect, the universe is always dynamic and interconnected, and our human observations always come with both bias and influence on what we study.

SYSTEMS RESEARCH CHALLENGES

One challenge from a research standpoint is how to adequately study entities which are much less stable and more context dependent than atoms and molecules. These kinds of entities not only change and evolve more rapidly, many have the capacity to learn and respond to being studied, or to anticipate and manipulate potential findings about themselves.

The concept of open systems implies more than simply "the exchange of information and resources between the system and environment." Systems and their (relevant) environments actually co-determine each other (that is, each helps define the boundaries or distinctions of the other). Some systems are spatially defined (e.g. the cells of an organ) but the elements of other systems may be physically dispersed (e.g. members of an organization). In the latter case, the elements of the system all adhere to the same principles of organization without being physically confined.

The broader implications have to do not only with systems and environments, but with their ongoing relationships. It is the stability of the relationships which perpetuate the ongoing pattern of the system, i.e. its form of organization.

How, then, do we adequately study such entities? Qualitative research methods (including phenomenology, grounded theory, action research, and others) offer alternative approaches for studying humans, but are considered to be less rigorous than quantitative methods in many academic realms. Methods such as System Dynamics attempt to capture relationships between variables, but are often limited (in this case, primarily to feedback between variables in the form of *stocks* and *flows*).

The very notion of an Anthropocene takes these questions to a new level. How do we begin to understand the many ways in which we as species are affecting the planet? The increase in population and our technological advancements are seen as triumphs of science and engineering. There is no larger perspective, though, about what we are creating and what the outcomes of that might be.

Governing the Anthropocene requires not only systemic understanding but systemic leadership. Systems Research is part of a portfolio of systemic approaches to help leaders and stakeholders assess, design, develop, implement, and evaluate programs for effective governance of the Anthropocene.

To address this latter question, two additional provocative questions concerning Systems Research have emerged:

1. What is missing in current research approaches that systems approaches can bridge?
2. Why does it matter?

This paper and its presentation will address these two questions by exploring the literature that has addressed the distinguishing dynamics of systemic approaches to research and problem solving. This retrospective will be the foundation for interactive dialogue with ISSS participants attending this session. The intention for this session is to develop a leadership path for Systems Research and its role in more effective governance of the Anthropocene.

HOW DO WE DISCOVER WHAT WE NEED TO KNOW, ACCORDING TO WHOM, AND FOR WHAT PURPOSE?

The purpose of this paper is to present ideas and provoke discussion about Systems Research. In preparing this paper, we attempted to focus on the primary questions posed in this statement: How do we discover what we need to know, according to whom, and for what purpose?
As researchers grounded in systems approaches to inquiry our first step was to review the existing work that has been done to date that relates to these questions. What we found was not surprising. Researchers and practitioners with a systemic mindset approach problems with multiple perspectives. A tremendous amount of work has resulted in a vast amount of systems thought, models, and practices to address problems in several disciplines, specifically anthropology, biology, communications, ecology, engineering, mathematics, philosophy, physical sciences, psychology, sociology, and others. Work in these area have resulted in understanding systems through cybernetics (communication, command, and control systems), socio-ecological systems, systems engineering, organizational systems, complex adaptive systems, family systems, and others. In practice, this knowledge is applied in such areas as artificial intelligence, service systems, health care policy, and change leadership.

With all this knowledge, one might erroneously think humans should be well prepared to address the vast problems facing life on this planet; however, it has become almost standard practice to preface research papers with commentary related to the urgency and complexity of these problems. We propose that the world has always been complex (meaning beyond the capacity of humans to fully understand); yet, it appears that the magnitude of complexity continues to increase. That perception has two likely sources. One is that we know more about what we don't yet know. (Our awareness of our ignorance has increased.) Additionally, the things that we have created in the world have in turn created new and different potentials than existed before.

We also propose that while science has been a powerful approach to unraveling some complexity, science takes a "reverse engineering" approach which limits its capacity to comprehensively address "messes"(Ackoff, 1997) in the real world. At some levels, science's strongest advocates and systemism's strongest critics fear moving out of the fields of certainty, even when their world view assumes stability, which is not reality, for their models to work.

There are two premises for this paper:

1. Everything is always changing.
2. It's all connected.

The scientific method relies on observing phenomena in isolation and assumes stability, the antithesis of these premises.

We ask ourselves and our colleagues, "What are useful ways of knowing and what would that look like given the premises above. What are we trying to get to in research?" Much research has become a scheme of funding and career perpetuation disconnected from the needs of society. We ask other researchers, "When you conduct a study or write a paper, what is it you are doing? What is produced in terms of knowledge and how does it fill a need for what we need to know? What are the implications? Who will determine what is considered good information? Is peer review sufficient (i.e. guarantor's of competence)? We need a high level of confidence in the data being used – is it there? Are we willing to give this (broken?) process the authority to be a guiding force for decision making on massive scales for humanity in the future? When feedback indicates errors, how will corrections be made effectively? What are the implications for ethics?

Figure 1 provides a very rough sketch for discussion. The lower left quadrant represents the "scientific method", including the basic tenants of traditional, quantitative research. These tenants continue to influence a majority of formal research which gets conducted today, often via

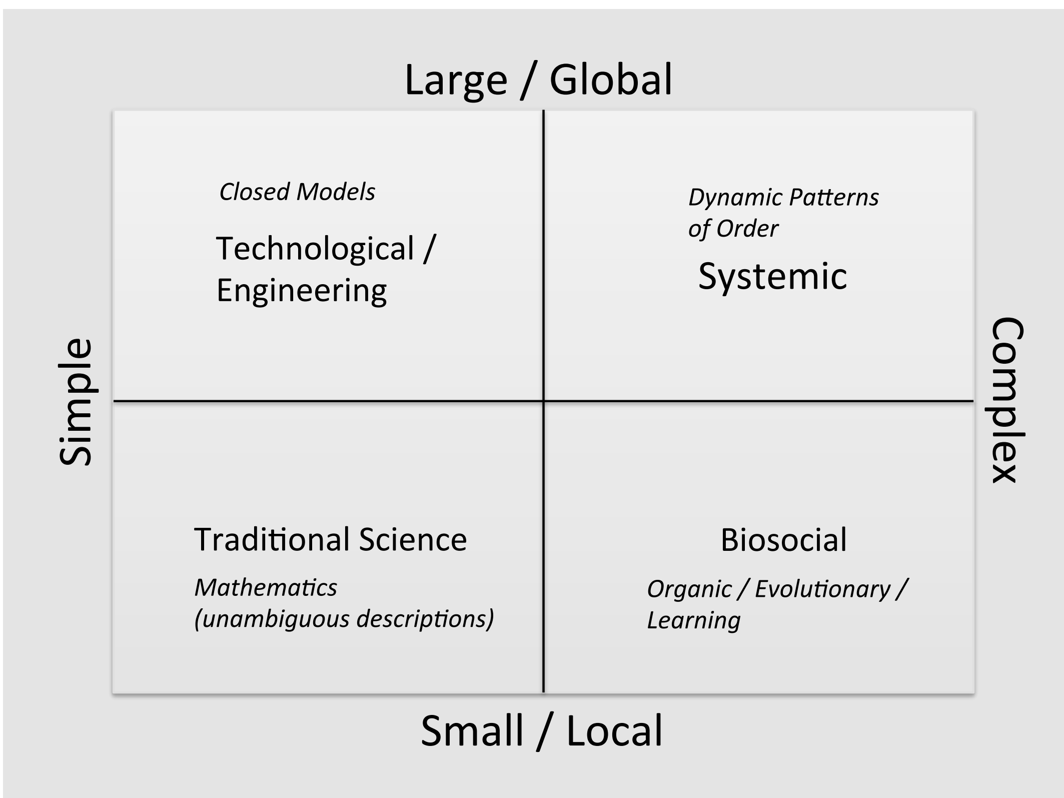

Figure 1. Scheme of four approaches to building knowledge

the bodies which fund the research. They also define the basic principles of research taught at many universities around the world, and the standards expected by most "top tier" professional journals in which academics hope to publish.

Missing from discussions about traditional approaches to research are the assumptions on which they are based. Studying variables by isolating them from externalities assumes that context is irrelevant, or at best, minimally relevant. Phenomena can be plucked from their environments, studied in-depth, and then applied back to the same or similar settings, at different places or points in time, with no loss of relevancy. This leads to what has been referred to as a mechanistic or "clockworks" view of the universe. Entities can be dismantled and reassembled, returning to their original functionality. They can be understood by simply studying the totality of their constituent parts. They work as expected if all of the parts are assembled appropriately.

This approach was adequate for studying the Newtonian universe. Atoms formed molecules, which created compounds. Carbon and silicon were basically the same substances, wherever and whenever they were found.

The same approach applied to human systems is questionable, at best. Management and organizational researchers, for instance, have studied leadership for decades. The number of theories about what creates a great or a successful leader would be difficult to count. Most have tried to determine a small list of characteristics that could be replicated by other individuals, causing them to become similarly successful. To-date, most of what has resulted has been an endless stream of studies and training programs related to leadership.

The upper left quadrant of Figure 1 represents the realm of technology, primarily driven through the many sub-disciplines of engineering. The reason for including this realm is two-fold. First, while engineers clearly distinguish themselves from scientists, they share many of the underlying philosophical assumptions. Both scientists and engineers work from closed, self-referential models. (Like software or video games, the internal rules coded into the programs determine what can and cannot happen; what exists or does not exist because of what has been included or excluded by the programmers.) Second, there has been a great deal of overlap in recent years as scientists have incorporated the use of computers and computer modeling in their research. The need for actual, empirical testing is being challenged by the abilities to run computer simulations at much greater speed and dramatically decreased costs than traditional experiments. The most recent challenge is very generally called Big Data, with its promise to begin replacing the human discovery process through the raw computing power of ever-faster mainframe machines.

The lower right quadrant represents the very messy natural world of our biosphere, from bacteria to the largest social systems. Unlike the left two quadrants, this realm does not have the luxury of isolating variables from their environments, or stopping time and controlling for unwanted factors – at least not in reality. Since the beginning of modern science, of course, there has been pressure for all "scientists" to adhere to the practices of physicists in terms of research procedures and presentation of findings. This created the concept of "reductionism," the need to ultimately explain all phenomena in terms of matter and energy. Over time, philosophers and non-physicists rebelled, citing the many reasons why these traditional approaches were not adequate to the phenomena being studied. The tenants of traditional science, though, continue to dominate expectations for research, whether stated explicitly or not.

The upper right quadrant of Figure 1 represents the realm of systems science, writ large. In our experience, there have been many attempts to address the factors and issues represented by this quadrant, but no clear research methodology or approach that has proven adequate.

At present, there seem to be two general categories of potential. First is a long and varied list of principles which are thought to apply to systems. This includes properties of emergence, non-linearity, and so forth. Second is a group of methodologies and practices, which include the term systems, or claim to be related to systemic concepts. These are the approaches familiar to many members of systems-related societies, including system dynamics, soft systems methodology, viable systems methodology, social systems design, etc. and etc. A particular approach to note is that of action research (or participatory action research), which even more than other research methodologies truly is a broad approach rather than a methodology, per se. Its development as an alternative approach to research and learning parallels much of the historical time, and included many of the theorists and writers, as the systems movement more generally.

All of these systemic approaches and practices are either based upon, or include, a host of practical, ethical and philosophical assumptions, which may be stated or not. Most of them incorporate aspects of human involvement and interpretation, or aspects of power and dominance, and therefore cross boundaries with the biosocial realm of Figure 1. Some use or rely on software technologies, crossing into the technological realm. Some attempt to approach the rigor of traditional scientific studies, but most would consider themselves to be an extension beyond traditional science, if not a separate alternative.

Taking all of this into account, what appears to be missing is an approach to research which explicitly includes the dynamic processes of systems and their environments, and the relationships essential to them. The ultimate requirements for accomplishing such an approach are still not clear. Theoretical biologists, from Bertalanffy to Rashevsky to Rosen and beyond used various forms of mathematics in their attempts to describe systemic processes. Are our current forms of mathematics adequate to the task?

Likewise, it is unclear how current or future computer technologies might be incorporated into either modeling or simulating systemic patterns and behaviors. (Given the relationships between mathematics and software, one seems to imply the other. If systemic behavior could be coded into a software program, it would need to be mathematically descriptive.) Once again, the question is the degree to which current technologies are adequate and simply need to be deployed, versus the kinds of development required in order to address the complexities involved in systemic descriptions.

WHAT IS NEXT FOR THE DEVELOPMENT OF SYSTEMS RESEARCH?

The intent of this paper has been simply to point to the need for further development in the ways that we learn about and describe the world around us. There is no assumption of proposed answers at this point in time. As a caveat, however, there is also no assumption that we need to dismiss or leave behind any of the ways in which we have learned how to learn thus far. The advances in human knowledge since the advent of modern science have been astounding. They simply remain limited.

We, as humans, know a lot, and we have developed incredible capabilities for affecting the world in which we live. To assume that we know enough to be responsible for the next phase of our planet, though, is folly. To believe that we *should* do whatever we find ourselves capable of doing is adolescent. Learning to govern ourselves through the Anthropocene will require both knowledge and maturity that we have yet to demonstrate, but need to begin working on immediately. What we are proposing is to undertake this task by developing tenants for Systems Research, which may, and likely will, include tenants from other disciplines as well as develop new approaches that transcend them.

THE PATH FORWARD: MORE CHALLENGES FOR SYSTEMS RESEARCHERS

Systems researchers, especially graduate students, sometimes choose a systemic approach to conducting research to further their learning and understanding of complex situations. They are in unchartered waters because there are no accepted Systems Research frameworks or foundations for design of research studies, including research approaches and methodologies. Here are some of the issues they encounter during the process of designing, conducting, reporting, and discussing the results of their research.

1. Desire for learning and understanding complexity
2. Desire to contribute significantly to the body of knowledge (BoK) in their discipline or field of interest
3. Desire to establish credibility as subject matter experts (SME) in their disciplines
4. Difficulties in communicating with clarity between levels of analysis (e.g. individual, collective, system)
5. Challenges and constraints of generalizability of findings (i.e. small sample, considerations of time (short term versus long term or longitudinal study) and space
6. Consistency
7. Scale-ability
8. Wrestling with balancing the accuracy and constraints of closed models (considered proof or reality)
9. Wrestling with fuzzy qualitative models that put aside quantitative assumptions, laws, and proofs in favor of "good enough" frameworks for understanding
10. Grappling with communicating the essence of dynamic systems, change over time, and evolution
11. Determining whether mixed methods (quantitative + qualitative methods) are suitable for studying the subject system to represent it as it operates in context
12. Understanding the limitations of different systems approaches (e.g. Systems Dynamics examines events, while Soft Systems Methodology is more appropriate for examining relationships)
13. Understanding the position (role) of the researcher as being an observer (standing outside the system) versus participant (an agent operating inside the system). For example, Action Research approaches like SSM and PAR are context dependent with researcher

acting as an agent inside the system. In Systems Dynamics, the researcher is an observer outside the system.

14. Grappling with the question of whether Systems Research should be working to the standards set by traditional science and scientific research
15. Understanding and documenting research biases (conscious and unconscious; e.g. intention to improve conditions and/or quality of life in a system – *benevolent bias*)
16. Grappling with research ethics

These issues can hamper systems researchers and graduate students alike. Continued development of frameworks and mental models that support systemic inquiry will be essential in the advancement of understanding complexity, as well as discovery and design of strategies to address wicked problems in the Anthropocene.

RECOMMENDATIONS FOR SYSTEMS RESEARCHERS

Our review of the literature focused on the merits and value of designing and conducting Systems Research as opposed to other approaches. We found that our colleagues have devoted significant time, effort, and thought that has been focused on these complex questions. Perhaps the most salient lessons taken from this review relate to the rationale for doing Systems Research and conducting it competently. These lessons include the following:

1. **Formulation of the question**(s) is (are) essential to the quality of research and results attained. Positivism searches for absolute answers in dualism (yes/no, positive/negative). Systemism organizes knowledge to develop rich pictures using dualism to compare, contrast, and inform results for high quality decision making. This distinguishes systemism as action oriented and non-linear from science, which organizes knowledge as explanatory and predictive conforming to natural laws. It is stochastic versus deterministic. The goal of science is prediction and control to attain stability, while the purpose for inquiry using systems approaches is development of understanding for improved conditions through constructive action and change (Boulding, 1954). In systems, the goal is relevant operating principles applied in context.
2. Systems Research focuses on **relevance** in terms of how systems operate in their environment, which considers *context* and *wholism*.
3. Recognize the **role of the researcher** as a possible disrupter (+/-) in the studied system, especially in participative action research.
4. Inquiry must be designed to be *systematic* and *systemic* to address complex problems. Research designed and conducted with these two principles in mind partially addresses concerns about **rigor**.
5. Discovering what we need to know is a community (e.g. interdependencies, stakeholders) effort (**relational**). It must be participative and not done in isolation.
6. **Trust** and **transparency** are essential in creating a community of inquiry that can engage in generative dialogue to form high quality questions.
7. Leadership of communities of inquiry must have **capacity for being comfortable with the unknown – ambiguous, uncertain, and latent**. This calls for managing expectations.

8. Leadership of communities of inquiry must understand the limits of anticipation and prediction. Omniscience is not the goal. Building competencies for learning from feedback is a better long-term strategy. This means instilling a regular practice of **reflection** - scanning the environment for change and checking the endeavor for relevancy.
9. Leadership of communities of inquiry must have **capacity to trust the emergent process of systemic inquiry**. If the community starts with high quality questions, the research process will reveal new questions that will inform the direction of the endeavor.
10. Leadership of communities of inquiry needs to instill a sense of confidence that human systems have **agency** to recognize when change needs to occur, adapt, and develop successful approaches that align with the current environment.
11. Distinctions of **formalization**. The success of the scientific (positivistic) model for conducting research can be attributed in part to its high reliability due to formalization through proven theories and natural laws (proof). Formalization is desirable in developing credible approaches to Systems Research; however, because the goals are different from positivistic inquiry, formalization will also be different. Specifically, the goals of Systems Research are to understand how systems work in context to improve conditions through change.
12. Recognition that increasing hierarchy through formalized processes and strategies also instills rigidity (reduced flexibility through perceived control) into systems. In human and bio-social systems, **resilience** is desirable. The assumption that technologies based in positivistic science are appropriate in human systems is a trap. Consciousness of ethics and fit to context are necessary in human systems.

CONCLUSION

This paper/presentation is organized around these considerations as well as the questions, “What is missing,” and “Why does it matter?" Further, we asked. “How do we discover what we need to know, according to whom, and for what purpose?”

As important as scientific methods and positivistic approaches are in conducting sound research and contributing to the advancement of understanding aspects of our world, the complexity of problems facing us, tell us that mechanistic approaches are not sufficient. The assumptions of science limit its ability to inform us about the nuances of the relational dynamics of our world. Some of these assumptions of science include:

- The universe is orderly and knowable.
- The universe and its elements are stable enough to be predictable.
- Evolution is the ongoing change of the original elements, and their emerging variations.
- Traditional science is a process of reverse engineering, in order to understand how our current reality came to be.

What we know now is that our world is complex and sometimes chaotic. Traditional science functions in time and space; however, humans have limited lifecycles and a propensity for meaning making. The idea that the universe is orderly and knowable provides a framework; however, it is a static scaffold that is useful for modeling in theory, but limited in application to living. In reality, the universe is dynamic and in a process of constant change. These attributes of change lend its variety, emergence, adaptability, and resilience. As humans in an ever-changing environment, like many systems, we seek stability. A consequence of stability is eventual dissipation and decay, which humans seek to avoid.

As humans negotiate this era of the Anthropocene, a systemic perspective can advance the quality of life through research that more aptly models the complex realities in which we live. In Systems Research a different set of assumptions and approaches is needed to effectively address the wicked problems ahead of us. We invite to join us in exploring these ideas during the conversation.

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