Chapter 3
Problem Structuring and Research Design in Systemic Inquiry

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Abstract The central question of this chapter is, "How are inquiries into problems structured and designed to conduct research in a systemic (holistic, comprehensive, complicated, and complex), as well as systematic (logical, rigorous, and disciplined) way?" The focus is on Problem Structuring and Research Design related to the purpose of research and development of an inquiry's central research question(s). Both are predicated on researchers' grounding in systems philosophy and theoretical or conceptual frameworks gained through knowledge acquired through review of the literature, experience, experimentation, or pilot study. These foundations prepare systems researchers for analyzing systems and defining problems to design, conduct, report, and evaluate systemic research studies. In addition, these fundamentals guide researchers' journeys through iterative, nested, and cumulative cycles of learning about subject systems. Researchers will learn about defining systemic research questions and gain understanding about the role and embedment of context, including a system's environment, its stakeholders, and emergent properties. Researchers will gain appreciation and competencies of systemic research that is also systematic by applying principles of adaptive project management. While Problem Structuring is about doing the right research, Research Design is about doing research right using a systemic lens. For systems researchers from disciplines such as the social, natural, and physical sciences, and fields like engineering, economics, and public policy, this question poses exacting challenges in evaluation of credibility, validity, and ethics of Systems Research including application of findings. It poses a dual standard of rigor in requiring that research meet both systematic and systemic definitions and distinctions.

Keywords Systemic • Systematic • Systems analysis • Cycles of learning • Stakeholders • Emergent properties • Adaptive project management • Credibility • Validity • Ethics

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> Don't get involved in partial problems, but always take flight to where there is a free view over the whole single great problem, even if this view is still not a clear one.
>
> (Wittgenstein, 1984, p. 23e)

Introduction

The previous two chapters of this guide have introduced you to Systems Philosophy and the role of Frameworks in developing a foundation for Systems Research. In this chapter, the focus is on Problem Structuring and Research Design related to the purpose of your research and developing your inquiry's central research question. The central question of this chapter is, "How are inquiries into problems structured and designed to conduct research in a systemic (holistic, comprehensive investigation), as well as systematic way (logical process and procedure)?" For systems researchers, as well as others from disciplines such as the social, natural, and physical sciences in addition to engineering, this question poses a rigorous challenge in the design and eventual evaluation of the credibility and validity of their work (Sheng, Elzas, Ören, & Cronhjort, 1993). It poses a dual standard of rigor in requiring that research meet definitions and distinctions both systematic and systemic (Carr, 1996; Ison, 2008).

Problem Structuring and Research Design are critical processes in the course of establishing the philosophical foundation, determining the appropriate framework, and developing the model used in your research. They serve as a bridge between the foundation for your research and the actions you take in conducting the study. These two processes relate to the potential and possibility of inquiry into systems through understanding its context, function, and structure to develop research questions through ontology and epistemology. These critical steps in the research process set the stage for action—conducting your research, analyzing the data you collect, and reporting results, which will be discussed in later chapters of this guide.

Is It a System?

Systems research requires deep understanding of a subject system or system-of-systems. In general, systems researchers identify subject systems with intentions of understanding how they organize and operate within their environments when both are changing. It is important to make the distinction between describing versus defining a system. Describing a system conveys attributes, characteristics, and dynamics of your subject to your audience as opposed to "defining a system," which is a generally accepted definition of what a system is. What a system is largely depends on its context. Describing your subject system is not synonymous with *defining a system* in the context of systems engineering, which details system specifications for the purposes of analysis, design, and development. In the context of systems research, describing your subject system entails explicitly explaining the context and interrelationships in which the system operates and the relevant boundaries you will examine within the scope of your research. As a systems researcher, you will likely use the definition of a system according to your discipline or based upon your thorough literature review of the systems sciences. This definition is a standard or benchmark for the purposes of your research and it is part of choosing your framework. Further, systems researchers will describe a particular system or details of the subject. This distinction is specific and contextual versus general. In addition, it is important to discern a "system definition," as it is used in systems engineering for specification of systems. In most cases, systems researchers are describing subject systems, not defining them unless developing philosophy and/or theoretical foundations.

When describing a subject system, you may find it useful to ask these questions:

- What definition of a system are you using to assess your subject?
- Does the subject have agency (consciousness is a characteristic of human systems, not necessarily other natural or physical systems)?
- How is it organized?
- How does it communicate internally and externally?
- How does it operate and regulate itself internally?
- How does it operate, adapt, and influence externally?
- What are its boundaries and thresholds for survival?
- How flexible or permeable are those boundaries?
- What are its interdependencies and relationships with its environment?
- What are the consequences of its existence and its extinction on the viability of the larger system (i.e., requisite variety, interdependence, holism)?
- What are the strategies that support and advance or dissolve and dissipate the system?

Seeing (understanding) systems means more than recognizing patterns by delving into the relationship between the levels of an entity's organization and operation within its environment to determine the scale, scope, and impact of its behavior in and on the system as a whole. Thus, investigating systems will entail examination of the subject's potentials for self-organization (Ashby, 1947), cybernetics (Ashby, 1956), hierarchy (Ahl & Allen, 1996), autopoiesis (Maturana & Varela, 1980), feedback (Sterman, 1989, 2000, 2002), adaptation (Holland, 1992; Gunderson & Holling, 2002), emergence (Goldstein, 1999; Hofstadter, 1979; Lewes, 1875; Steels, 1990), and learning (Argyris & Schön, 1992). Ultimately, an underlying question is, "Can the whole be expressed as a sum of its parts?" If not, then the subject may be a system. As a systems researcher, your role as primary investigator is to explicitly explain the essence of the system. The challenge for most systems researchers is developing an explicit description with parsimony (Popper, 1992; Wittgenstein, 1922; see Chapter 2).

A Systemic Perspective

In essence, a systemic perspective enriches your research on two levels by addressing an inner logic and an outer logic (see Table 3.1). Using inner (internal, subject specific) logic, a systems perspective contributes theories, methodologies, methods and tools. Using outer (external, systems environment) logic, a systemic perspective relates your subject system to its relevant context and its stakeholders. This perspective may be described as a project management aspect of research. Applying a systemic perspective to research in terms of project management may be novel to research. Based on experience, project management can be beneficial for the research as well as for the researcher.

Table 3.1 Systems perspective integrating inner and outer logic

Doing/logic	Doing the *right* research (Problem structuring)	Doing the research *right* (Research design)
Inner logic (research system)		
Outer logic (stakeholder and environment)		

Problem structuring and designing your research is a learning cycle. Each of the four perspectives in the above table will inform the other three. It will concomitantly limit and provide new possibilities. Using these perspectives to shape your inquiry prepares you for decisions which will further shape your research and determine the course of action. The better you structure your problem and design your research, the more likely your research will yield useful and relevant outcomes.

Much of Problem Structuring and Research Design entails questions you will be asked as the primary investigator by your audience, including the Institutional Review Board (IRB), your dissertation/thesis committee, your funders, your constituents, your colleagues, and those either reading and/or applying your findings, such as decision and policy makers in governance. Having a clear sense of how you will address these questions will provide a solid foundation for conducting, analyzing, reporting, and evaluating your research.

Suggestion

- During the course of developing your research study, you will make many choices and decisions that will have consequences on the direction and outcome of your research. It is wise to keep a journal chronicling the rationale you used for making choices and decisions. Keeping a journal of your decisions will help you reflect upon them during your analysis of the data. You will also find it a source of possible recommendations for future research.
- Debriefing after a research study is completed enhances your learning, as you develop future research strategies based upon what happened, what did not, and what could have been done differently.

Problem Structuring

Problem structuring entails explicit articulation of details of the rationale for your inquiry and its design with your audience. As John Dewey (1938) said, "A problem well put is half-solved" (p. 108).

According to Woolley and Pidd (1981), problem structuring is "the process by which the initially presented set of conditions is translated into a set of problems, issues, and questions sufficiently well-defined to allow specific research action" (p. 197). While Wooley and Pidd's target audience was practitioners in Operations Research (OR), their problem structuring rationale applies to systems research because of its focus on complex, real world or *wicked problems* (Churchman, 1967; Rittel & Webber, 1973, p. 160), and the essence of such fundamental questions as:

- What is the real problem?
- How do you know you are working on the right problem?
- How do you decide what to do about the problem?
- How do you set limits to the area of investigation in a project? (Woolley & Pidd, 1981, p. 197)

Answering these four fundamental questions will help you determine your central research question and subsequent questions, the relevance of your research and its audience, the scope of the subject system and the scope of your research, as well as methodologies for research design and data collection with a high potential to lead to deeper understanding of the problem and strategies for addressing it.

Suggestion

- Be explicit and crystal clear in communicating your primary and secondary research questions. Keep them straightforward and uncomplicated. Even the best articulated questions can quickly become complex as your research study unfolds. The KISS (Keep It Simple and Straightforward) principle will help you stay out of rabbit holes and digressions from the primary purpose of your research. This may take some intellectual distillation on your part, so you hone your inquiry to its essence. It may be useful to test your questions by asking for guidance from others whom you trust. A pilot study can help you refine your research questions.

In planning research that is systemic, as well as systematic, you will want to answer several questions early on in the development of your inquiry. These include:

- What is the purpose of your inquiry? Why is it important and for whom does it matter?
- What compels your inquiry? What is driving you to find answers? What is your motivation?

- Why are you asking these questions now?
- Who is your target audience for reporting the results of your inquiry and why will they be interested in its outcomes. This is the “So what?” question to which your audience and committee will want clear answers from you.
- What is the basis or foundation for your inquiry?
- What is known about the subject? What is yet to be known?
- What is the current situation? What is the gap? Will your research propose a way to bridge this gap or is that not yet anticipated?
- How are you describing the subject system, its context, its boundaries, its space–time–meaning dimensions?
- Does the subject system include human actors? If so, how will they be involved in the study and how will they be protected? Explain the ethical implications of your research.
- What other actors are in the subject system and how will they be protected or ethically addressed?
- Do you have anticipated outcomes? If so, what consequences of your research do you also anticipate?

In the early stages of developing your research ideas, you might find tools such as radial (e.g., mind or concept) mapping (Davies, 2011) or design thinking tools (Brown, 2008) useful in conceptualizing and/or visualizing your research. By seeing your ideas in a relational way, you gain insight into interconnections you may overlook using linear approaches. You will discover concepts that need exploration and development, which will help you choose your strategies for problem structuring and research design.

Figure 3.1 is an example of the use of mind mapping to capture and organize your thoughts about your research as early steps in the problem structuring and research design phases. This figure shows an early mindmap of the conceptualization of this book. As you develop your ideas further, you may want to consider other cognitive approaches such as DSRP (distinctions, systems, relationships, and perspectives; Cabrera, Cabrera, & Powers, 2015).

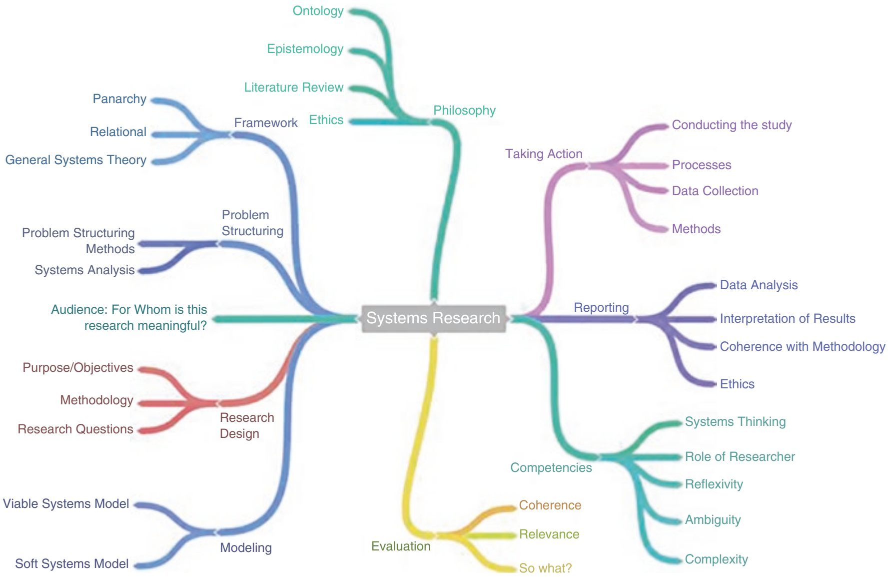

Fig. 3.1 Mind mapping of problem structuring for research design

Problem structuring can help you develop your responses to these questions. Rosenhead (1996) began by asking, "What is the problem" (p. 118)? To understand how problem structuring can help you answer this question for your inquiry, history will provide some understanding.

The legacy of problem structuring stems from OR and Management Science (MS) since the late 1960s. Initially, methods used for problem structuring emphasized objectivity; however, systems thinkers like Churchman (1967), Ackoff (1979), and Checkland (1983), were critical of this approach because it constrained application to well-defined problems. As systems thinkers, all three recognized its flaws as the complexity of real world problems advanced. In particular, Ackoff (1981) recognized most real world problems as "messes." As Rosenhead (1996) stated, "Problem structuring methods provide a more radical response to the poor fit of traditional OR approaches for wicked problems—a response based on the characteristics of swamp conditions rather than on the preexisting investment in high-tech solution methods" (p. 119).

Problem structuring methods (PSM) are better suited for situations that are characterized by unstructured hierarchies, sophisticated actors, nonlinearity, unpredictability, and changing priorities. As such, problem structuring lends itself to modeling complexity graphically rather than algebraically or quantitatively (White, 2006). Mingers and Rosenhead (2001, 2004) summarized the application of problem structuring as being well suited to unstructured problems characterized by:

- Multiple perspectives,
- Incommensurable and/or conflicting interests,
- Important intangibles, and
- Key uncertainties (Mingers & Rosenhead, 2004, p. 531).

Problem structuring is a way of modeling a situation (a model or multiple models), so participants can “clarify their predicament, converge on a potentially actionable mutual problem or issue within it, and agree [on] commitments that will at least partially resolve it” (Mingers & Rosenhead, 2004, p. 531). Mingers and Rosenhead (2004) advise that the application of problem structuring should:

- Enable several alternative perspectives to be brought into conjunction with each other;
- Be cognitively accessible to actors with a range of backgrounds and without specialist training, so that the developing representation can inform a participative process of problem structuring;
- Operate iteratively, so that the problem representation adjusts to reflect the state and stage of discussion among the actors, as well as vice versa;
- Permit partial or local improvements to be identified and committed to, rather than requiring a global solution, which would imply a merging of the various interests (Mingers & Rosenhead, 2004, p. 531).

The following is a summary of several PSM, from Rosenhead (1996) and Mingers and Rosenhead (2004) (Table 3.2).

Table 3.2 Summary of problem structuring models

Model type	Description
Decision conferencing	“is a variant of decision analysis. Through collaboration, it builds models to support choices between decision alternatives, especially in cases with multidimensional consequence when there is uncertainty about future events likely to impact outcomes. In a facilitated workshop, a group develops a model including probabilities and utilities with a goal of shared understanding, purpose, and commitment to action (Phillips, 1989, 1991; Watson & Buede, 1987).” (Mingers & Rosenhead, 2004, pp. 532–533)
Hypergame analysis	“is an interactive approach to taking action in conflict situations. It emphasizes (a) exploring the pattern and nature of interactions between the actors, and (b) the effect of differences of perception among the actors about what actions are possible, about preferences between outcomes, and so forth (Bennett & Cropper, 1986).” (Rosenhead, 1996, p. 121)
Interactive planning (also called idealized planning)	“is a method with the ambitious aim of designing a desirable organizational future and ways of bringing it about. Analysts generate a reference scenario to demonstrate the dire consequences of not taking action. This motivates a participative process in which participants create an ideal design for the future of their organization. Otherstages of the method deal with how to bring this future into existence (Ackoff, 1979, 1981).” (Rosenhead, 1996, p. 121)
Metagame analysis	“is an interactive method of analyzing cooperation and conflict among multiple actors. Analysts using supporting software work with one of the parties. They elicit from them decision options for the various actors, from which they construct possible future scenarios. Analysts and actors use these as a framework to explore their ability to stabilize the outcome at a more preferred scenario, by the use of threats and promises (Howard, 1993).” (Rosenhead, 1996, p. 121)

(continued)

Table 3.2 (continued)

Model type	Description
Process theory	"is an approach to science, perception, and measurement developed by Rosen (1978, 1991) using a modeling relation of encoding and decoding. It is applied in anticipatory and complex systems (Mikulecky, 2010)." (Rosenhead, 1996, p. 121) The modeling relation is explained in Chapters 2 and 4.
Robustness analysis	"is an approach that focuses on maintaining useful flexibility under uncertainty. In an interactive process, participants and analysts assess the compatibility of alternative initial commitments with possible future configurations of the system being planned for, and the performance of each configuration in feasible future environments. This enables them to compare the flexibility maintained by alternative initial commitments (Rosenhead, 1980)." (Rosenhead, 1996, p. 121)
Soft systems methodology (SSM)	"is a general method for system redesign. Participants build ideal-type conceptual models, one for each relevant world view. They compare them with perceptions of the existing system in order to generate debate about what changes are culturally feasible and systemically desirable (Checkland, 1981; Checkland & Scholes, 1990)." (Rosenhead, 1996, p. 121)
Strategic assumption surfacing and testing	"is a method for tackling ill-structured problems where differences of opinion about what strategy to pursue are preventing decision. Participants are divided into groups, each of which produces a preferred strategy and identifies the key assumptions on which it is based. The reunited groups debate these strategies and assumptions, mutually adjusting their assumptions on the way to an agreed solution (Mason & Mitroff, 1981)." (Rosenhead, 1996, p. 121)
Strategic choice approach (SCA)	"is a planning approach centered on managing uncertainty in strategic situations. Facilitators assist participants to model the interconnectedness of decision areas. Interactive comparison of alternative decision schemes helps them to bring key uncertainties to the surface. On this basis, the group identifies priority areas for partial commitment and designs explorations and contingency plans (Friend & Hickling, 1987)." (Rosenhead, 1996, p. 121)
Strategic options development and analysis (SODA)	"is a general problem identification method that uses cognitive mapping as a modeling device for eliciting and recording individuals' views of a problem situation. The merged cognitive maps provide the framework for workshop discussions, and a facilitator guides the group towards commitment to a portfolio of actions (Eden, Jones, & Sims, 1983)." (Rosenhead, 1996, p. 121)
Systems dynamics (SD)	"is a way of modelling people's perceptions of real-world systems based on causal relationships and feedback. It was developed as a traditional simulation tool but can be used, especially in combination with influence diagrams (causal–loop diagrams), as a way of facilitating group discussion (Forrester, 1994; Lane, 2000; Vennix, 1996)." (Mingers & Rosenhead, 2004, pp. 532–533)
Viable systems model (VSM)	"is a generic model of a viable organization based on cybernetic principles. It specifies five notional systems that should exist within an organization in some form—operations, co-ordination, control, intelligence, and policy, together with the appropriate control and communicational relationships. Although it was developed with a prescriptive intent, it can also be used as part of a debate about problems of organizational design and redesign (Beer, 1984; Harnden, 1990)."(Mingers & Rosenhead, 2004, pp. 532–533)

Beyond traditional PSM, there are other methods for analyzing problems: critical systems heuristics (CSH; Ulrich, 2000), SWOT analysis (Weihrich, 1998), scenario planning (Schoemaker, 1998), the socio-technical systems approach (Cytrynbaum, Trist, & Murray, 1995; Emery & Trist, 1965; Trist & Murray, 1993), "organizational culture assessment" (Schein, 2004, pp. 337–348), and resilience assessment (Gunderson et al., 2010).

In addition, multimethodology uses multiple problem solving and research methods (pluralistic) to leverage strengths while mitigating weaknesses of individual, often isolated methods for robust analysis (Mingers & Brocklesby, 1997; Munro & Mingers, 2002).

Clearly understanding and explicitly describing the system you will be studying is a critical process in problem structuring and determining the relevance of your research. In considering the subject system, your analytical stance will determine the extent of *systemicity*, the complex and dynamic behavior of systems and systems-of-systems, or "Weltanschauung" (comprehensive worldview), you will address in the analysis of your findings (Checkland, 2000). The scientific method isolates phenomena, relies on objective observation, and tests hypotheses. The scientific method views phenomena in controlled environments, which are considered *closed* systems (see Chapter 8 Evaluation). Boundaries are rigidly defined and fixed. The goal is to understand the individual phenomenon alone, not holistically. One of the most compelling reasons for adopting a systemic approach to inquiry is the complex nature of phenomena in the context of their environments. If complexity is driving your inquiry, then your perspective will be viewing the subject system as *open*, which accounts for phenomena operating in context of the natural environment with flexible or permeable boundaries (Ackoff, 1971; Forrester, 1994; Ulrich, 1995).

In analyzing problems in open systems, description of the subject system must account for the dynamics and interrelationships between relevant stakeholders. In addition, the description must explicitly describe the dynamics of environmental change and its impact on the phenomena.

Role of the Systems Researcher in Problem Structuring and Research Design

Consider your role as systems researcher and explicitly communicate it with your audience. This includes understanding your motivations and intentions in conducting your research (Conneeley, 2002; Munkejord, 2009).

Questions you will want to ask yourself include:

- What is my position or stance relative to the system to be studied?
- Am I *in* the system, but not *of* the system? Or, am I an agent of change *relative* to the system?

- Will my role be any of the following:
  - *Observatory*
  - *Participatory*
  - *Interventionist*
- What is the extent or degree of agency I will have in the system?
- How will I account for my presence, influence, and impact in/on the system?
- What are the risks of being *in* or *of* the system? Am I at risk for "going native?"
- What is the extent of benevolent bias (i.e., intention to influence the system for improvement; Elliott, 1977)?

Examples: Retrospective Case Study (Yin, 2013), Grounded Theory (Charmaz, 2014), Repertory Grid (Fransella, Bell, & Bannister, 2004; Jankowicz, 2003) as opposed to Action Research (Reason & Bradbury, 2001; Stringer, 2013) and PAR (McIntyre, 2007; Whyte, 1991).

Rationale for Systems Research

Developing well-reasoned arguments (Weston, 2009; Weston & Morrow, 2015) is an essential process for communicating the rationale for your inquiry. Through this process you will be using different types of reasoning to create a foundation for your research that is systematic, systemic, and sound. A suitable rationale for your research may suggest specific methodological and scientific frameworks. Be mindful of your decisions. Specific frames of reference suggest specific rationalities. While frameworks offer useful structure and support the communication of meaning, once you have chosen to work within a specific framework you also tend to be constrained. It is important to explicitly recognize and acknowledge the limitations and delimitations of the framework you choose.

As a Systems Researcher, it is important to understand and apply different types of reasoning, as well as distinctions about causality and the use of analogies and metaphors. In the process of conceptualizing your research, it will be useful to you to understand different types of reasoning and inference, so you can choose research approaches, apply research methodologies, develop research methods, or combine them, as in mixed methods research. As humans, we are sense- and meaning-makers (Weick, 1995). Our drive to understand our environment, our interrelationships with it, and one another, is at the heart of research. Therefore, it will be important to understand the relationship between inference and causality. Here are some distinctions:

Abduction (abductive reasoning or inference) is a form of logical inference in which a theory is based upon observation and finding the most uncomplicated and likely explanation. Examples of application of abductive inference are artificial intelligence, computer science, and expert systems. Philosopher and pragmatist, Charles Sanders Peirce (1839–1914) was an early proponent of abduction in which an explanation from an observation is made as a matter of course. In vernacular, this is referred to as an "obvious conclusion." Abduction does not guarantee a correct conclusion based upon its premises. For example, an observation of wet dog paws after a dog comes indoors from outside in the morning may indicate that it had rained. It may also indicate morning dew, sprinklers had irrigated the lawn where the dog walked, the dog had stepped in its outdoor water bowl, or that someone had cleaned its paws. Abduction is frequently combined with other forms of reasoning, such that Carson (2009) remarked that Sherlock Holmes did not rely solely on deduction but in concert with abduction and induction.

Deduction (deductive reasoning or inference) is a form of logical inference in which premises are directly linked to a certain conclusion. Examples of deduction, which is also referred to as reductionism, is most scientific research, geometry, and mathematical proof (as opposed to mathematical induction). Aristotle (384–322 BCE) is generally recognized as the developer of this logic. Deduction conforms to one or the other of three laws:

1. Detachment—a single conditional statement is combined with a hypothesis to deduce a conclusion, or
2. Syllogism—two conditional statements form a conclusion, or
3. Contrapositive—a conclusion is proven false, then the hypothesis is also false.

Historically, deduction uses a closed system assumption (i.e., what is known is true, what is not known is not true) as opposed to an open system assumption (i.e., lack of knowledge does not presume falsity; Reiter, 1978). Other examples of deduction are causal conditional or "if-then" and "if-then-else" statements. Applications of deductive inference include criminal investigations using biological evidence such as DNA. Both scientific research and forensic science rely on validity and reliability of their arguments.

Induction (inductive reasoning or inference) is a form of inference in which a theory emerges from observing patterns and then looking for evidence. It is often defined as reasoning that develops general principles from specific observations. It is particularly useful in the early stages of new theory development when little is known about a phenomenon.

Suggestion

- While Sherlock Holmes was considered a master of deductive reasoning, he relied on induction and abduction too. As a Systems Researcher, Holmes's application of these three types of reasoning was grounded in good judgment; however, his data collection techniques were often caustic, especially when human actors were involved. Avoid adopting Holmes' high functioning sociopathic approach when working with human actors because it will limit the richness of the information and data you collect. During problem structuring, you may interview stakeholders who understand the intricacies of the system you want to study. Using your social emotional intelligence (Goleman, 2006) will help you develop an accurate description based upon the information you are able to gather. For more about competencies of systems researchers, see Chapter 7.

Causation is the relationship between cause and effect. Causality is an inference that an effect has a direct or indirect cause. David Hume (1711–1776) and John Stuart Mill (1806–1873), two philosophers, made distinctions about causation. Hume brought attention to the errors in causal beliefs, noting that conditional statements can obscure true causation and, therefore, are insufficient. Hume noted that we have limitations in our capacity of observation and may overlook other attributes. Mill devised five criteria for confirmation of causality: (a) agreement, (b) difference, (c) joint agreement and difference, (d) concomitant variation, and (e) residues. Reliability of these criteria rests on relevance to the subject system under observation. These criteria of induction may be best applied to confirm observation of patterns for development of theories that may generate hypotheses. Inductive reasoning is a foundation used in Grounded Theory (Glaser & Strauss, 1967) and other qualitative research methods (Creswell, 2012, 2013; Creswell & Clark, 2007).

Suggestion

- One of the competencies (see Chapter 7) of adept systems thinkers is the capacity to hold two or more seemingly disparate ideas and reconciling them. This is the case with emergence, problem structuring, and research design. Anticipate emergence, trust the process, be prepared to articulate the unanticipated and unintentional consequences of your research for yourself and your subject system (reflexivity). Think about incorporating feedback for learning.

Creating Shared Meaning: Metaphors, Similes, Analogies, Allegories, and Isomorphisms

In the processes of problem structuring and developing your research design, your interactions with stakeholders in the subject system will be critical in developing an accurate understanding and description of the systemic issues of your inquiry. Much of this interaction is dependent on your ability to create meaning and shared understanding with stakeholders. In addition to frameworks and models, systems researchers often rely on metaphors, similes, analogies, and allegories to communicate complex ideas in comparative ways so their stakeholders and audiences can relate conceptually. Systems researchers also use isomorphisms to illustrate relationships between concepts or models.

A *metaphor* is a comparative figure of speech to relate two ideas using one to mean another. For example, "S/he is burning the candle at both ends," infers exhaustion. When someone says, "Soon I will feel right as rain," it is not taken literally but figuratively. Similes are types of metaphors that compare two things to create new meaning. For example, "S/he sprints like a cheetah," explicitly compares two different things using "like" or "as."

An *analogy* is similar to a metaphor, yet more complex, because it infers a logical argument of likeness that extends beyond initial comparison. Analogies compare similarity through shared characteristics, features, structures, or functions. For example, mechanical systems like cars are often used to illustrate similar human body functions for simplicity, such as food is fuel for the body. In outlining rules for arguments, Weston (2009) demonstrated the use of analogy. He argues that human bodies are like cars as follows: Medical professionals often attempt to convince patients of the merits of annual physical exams by suggesting that these exams are like taking a car in for regular service (p. 19). Since people value the functioning of their cars, the argument follows that they will have similar regard for the health of their bodies. *Allegories* extend beyond analogies. They use narratives to infer covert meanings and motivations, sometimes with moral or political undertones.

In general, *isomorphisms* are understood to be correspondences or parallels in form, structure, and/or function. In biology, isomorphisms are similarities of form and structure between organisms. In organizations, isomorphisms are similarities between the processes or structures of one organization with those of another by imitation or independent development under analogous constraints (e.g., context and boundaries).

Suggestion

- Use of mechanical analogies and metaphors fall far short of accurate parallelism with the dynamics of complex systems for most systems researchers. Going beyond two-dimensional media using new ways to communicate systemic properties and dynamics is necessary. Consider exploring technology for modeling and simulation using media like video and 3-D printing that can provide a robust way to share meaning with your target audience.

Three types of institutional isomorphism are: normative, coercive, and mimetic. Byrne (1998) defined isomorphism in the context of complexity theory in the social sciences:

> This term applies at the point where ontology and epistemology meet in practice in any scientific description of the world, although it is most usually applied in relation to quantitative description. A description and the world are isomorphic when the elements of the description correspond to entities in the real world and when the rules describing the relationship among elements in the description correspond to actual relationship among entities in the real world. The quantitative consideration of isomorphism depends on the transformation of uninterpreted into interpreted axiomatic systems. Abstract mathematical systems in which the terms in equations have no meaning outside the mathematical system are "uninterpreted axiomatic systems." When the terms in the equations are considered to describe real entities and the relationships among them, then the system is interpreted and is only valid if the abstract mathematics are isomorphic with reality. Usually this sort of discussion is conducted in relation to measurements at the ratio scale level and the generation of law like rules taking the form of equations, but it is equally applicable to simple typology generation and the representation of reality, not through equations, but the geometrical depiction. (p. 173)

As François (2004) notes, Stafford Beer made the distinction of *cybernetic isomorphism* as a recursive property of viable systems. Keep in mind that in mathematics, isomorphisms (equivalents) are homomorphisms or morphisms that admit an inverse. An automorphism is an equivalent whose target and source coincide. Depending on your subject system and audience, recognize these distinctions and be prepared to address them.

Understanding the use of inference and conceptual models to convey meaning to create shared understanding is part of the process of problem structuring that segues to Research Study Design in Systems Research. As a systems researcher, you will want to use inference and conceptual models judiciously to help your audience understand the nature, scope, and implications of your work. In the next section, Research Study Design is further explained.

Research Study Design

Research design is an explicit plan detailing the activities that you will undertake to obtain data and perform analysis to develop answers to your inquiry, specifically your research question(s). In your research design, you will articulate and illustrate the path you will take to enroll participants, collect data, analyze data, and report your findings. This section focuses on the planning process you use to create and develop your research study design. It will address the question, "What type of research design, including approach and methodology, is best suited systematically and systemically to investigate the subject system based upon the outcomes of your problem structuring analysis?"

Some of the most frequently used research design types depend on the purpose of the research and include:

- Review—literature review, systematic review for knowledge gathering and theory or hypothesis development;
- Descriptive—case studies, narratives, and ethnographies;
- Correlation—controlled case study, observation;
- Semi-experimental—experiments performed in the field;
- Experimental—controlled and double-blind studies used in scientific research;
- Meta-analysis—comprehensive review of studies examining the same research question(s).

Other considerations are context and duration in which phenomena are observed and data are gathered. For subjects sharing a profile of characteristics, a cohort study may be used to examine patterns. In cross-sectional studies, a specific population or representative subset is chosen to identify causal effects. Longitudinal studies rely on repeatability of prior research studies and examine correlations over the long-term. Cross-sequential studies combine cross-sectional and longitudinal designs, thereby reducing the inherent issues with both.

How will the study be conducted? What methodology will be used? What methods will be used? You may consider fixed design, such as experimental using dependent and independent variables with control, or non-experimental including correlational/relational and comparative, or flexible design, for example, case study, ethnography, grounded theory using quantitative, qualitative, or mixed methods.

New systems researchers may find choosing a research methodology to be overwhelming considering the variety of approaches available. As you consider different research approaches, you will want to consider the following:

- Is the inquiry confirmatory? That is, since the interrelationships are known between variables or actors, will a higher level of confidence be achieved with the results of additional study? Will an *a priori* theory or hypothesis be tested? In this type of inquiry, emergent phenomena are neither sought nor accounted for in the data analysis and reporting.
- Is the inquiry exploratory? That is, will potential interrelationships between variables or actors be examined? Will an *a posteriori* theory or hypothesis be generated from the exploration? In this type of inquiry, emergent phenomena are analyzed and accounted for in the data analysis and reporting.

As part of problem structuring, you will have described the subject system and your position or stance relative to it (i.e., observatory, participatory, interventionist) and the extent of your agency (influence) during your research study. In addition to understanding the relationships of the system, your Research Study Design accounts for other information you have gathered through the Literature Review and how you will integrate that information (if at all) in your analysis. In your Research Study Design, you explain your systemic perspective or the lens/lenses you will use to gather and analyze data in the subject system.

In some Systems Research, the literature review provides theoretical basis for research questions. Determination of your theoretical grounding should be not only rigorous, but systemic. You may choose more than one theory because one alone is not sufficient. If you choose to compare and contrast theories, possibly to develop new theory, then you may decide to use theoretical pluralism (Midgley, 2000). Buds of theory development can be observed through qualitative investigation using several approaches including theoretical pluralism. The extent to which you apply the knowledge you gain through your literature review depends on the degree of inductive reasoning you will be using through the research methodology you choose.

For example, if you choose *grounded theory* (Glaser & Strauss, 1967), then its highly inductive approach means your literature review provides essential information about the system itself but will not determine the specifics of your research questions. Inductive research designs are intentionally ambiguous to elicit emergent properties within systems. As a systems researcher, you will not be explicit in your questions (i.e., they will not be closed-ended hypotheses for testing, but open-ended inquiries). You will be explicit in how you intend to address emergent phenomena. In your Research Study Design, you need to clearly answer the following questions:

- How will emergent properties be addressed?
- Once revealed, how will emergent properties be confirmed or disconfirmed?
- How will emergent properties be tracked and reported?

Systemic Research Design inherently involves complexity on multiple levels ranging from your view of the subject system as a systems researcher to integrating emergence on a personal level. Most likely, it is all connected; however, clarity about your role as researcher in conveying the most relevant information about your subject system is your primary responsibility to the system and to your audience.

Suggestion

- Emergence during your research study is likely to occur in the subject system. While you can anticipate that emergent phenomena will occur, it is unlikely you will be able to anticipate exactly how it will appear and what it will look like. As a systems researcher, on the research study level, be astute to take notes of when unanticipated activities and behaviors occur in the subject system and its context. Based on your preference, your notes may be compiled in a journal or more formally tracked using software of your choosing. If you are using qualitative data analysis software (QDAS) such as atlas.ti or NVivo, you may choose to develop codes to track emergent phenomena. Emergent data are valuable when you complete data collection, compile your results, and reflect on your findings. In Systems Research, the emergent data can be as or more informative than the data formally collected in direct relation to the research question(s).

During this phase, you will consider how you will collect and analyze the data through several questions:

- What data are required?
- How will the data be acquired and collected?
- What methods meet the requirements of data collection and analysis of the inquiry systemically and systematically?
- What analytical approach will be used (e.g., critical systems heuristics, Ulrich & Reynolds, 2010, methodological pluralism—mixed methods, Midgley, 2000)
- Will you use multiple levels of analysis or other analytical approaches? If so, which ones?
- How will you document your data collection and analysis process?
- What technologies will you use to help you organize and analyze the data (e.g., SPSS, STATA, SAS, altas.ti, and NVivo)?
- How much will you rely on qualitative or quantitative data analysis software to perform the analysis?
- How close to the data do you expect to be during transcription or other compilation processes?

While you may not know what to expect during the course of your research study, you can be explicit about your processes of data collection and analysis.

Anticipating the unexpected lies not in knowing the details beforehand but knowing what to do with the knowledge you have gained and communicating with your target audience.

Suggestion

- You may find that you are dealing with emergence on multiple levels during your research. As a systems researcher, on a personal level, you may encounter several "surprises" or incidents that you did not expect during the course of your study. It is best to plan for and expect the unexpected and take it in stride knowing that these occurrences are part of your learning process as a researcher. Do what you can to be proactive, giving yourself space to recover from unanticipated events, yet do not fear them. They are often the richest part of your research journey.

Through clear and explicit Problem Structuring and Research Study Design, systems researchers create a foundation for rigorous research that can lead to creative problem solving and systemic intervention (Flood & Jackson, 1991) to address wicked problems.

Summary

To understand wicked problems confronting the contemporary world, systems researchers need the knowledge, skills, abilities, capacities, and competencies to develop keen insight into issues. This expectation demands Problem Structuring and Research Design that go beyond traditional approaches to research and are not only rigorously systematic, but robustly systemic. This need calls for systems researchers who can assess these problems accurately and communicate the implications to audiences clearly. In addition, systems researchers may need additional skills in evaluating subject systems for adaptability and resistance to change (i.e., adaptive capacity), especially in complex adaptive systems interconnected with complex adaptive social systems (Edson, 2012).

Problem Structuring is a critical step in visualizing, articulating, and documenting the major purpose, motivation, and questions driving your inquiry. The clarity in which you conceive of the research questions sets the stage for your Research Design. Essential questions you need to ask are:

- What is the purpose of the inquiry?
- Why is it important?
- Who will use the research findings?
- What is the scope of the research?
- What are the limitations and delimitations of this research?
- What contribution does it make?

- What are the implications of research that is inconclusive?
- How will emergent phenomena be handled?

By comprehensively understanding and describing the system you are studying through Problem Structuring and Research Design, you develop a rigorous approach to conducting Systems Research that is both systematic and systemic. In Chapter 4, Modeling will be introduced. In concert with Problem Structuring and Research Design, Modeling can help you explicitly communicate the complexity of your inquiry with your audience because models help create shared meaning (Weick, 1995) leading to shared, collaborative action, as explained in Chapter 5.

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