

SYSTEMS THINKING FOR KNOWLEDGE

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The capacity to engage in systems thinking is often viewed as being a product of being able to understand complex systems due to one's facility in mastering systems theories, methods, and being able to adeptly reason. Relatively little attention is paid in the systems literature to the processes of learning from experience and creating knowledge as a direct consequence of individuals engaging systems thinking itself over time. In fact, the potential efficacy of systems thinking to improve performance normally seen as only contingent on *a priori* knowledge, rather than knowledge created via learning from experience. Such newly create knowledge often results from engaging in modeling efforts and systemic forms of inquiry. This article proposes a model for creating new knowledge by coupling systems modeling with a pragmatic approach to knowledge-creation. This approach is based on a foundation of the pragmatic concepts first proposed by the American philosopher/scientist Charles Sanders Peirce over a century ago. This model offers systems practitioners a framework to engage in knowledge-intensive systems thinking (KIST) for addressing complex problematic issues.

KEYWORDS: *Action learning, knowledge, modeling, pragmatic, systems, systems thinking.*

INTRODUCTION

What is the purpose of systems thinking? The knee-jerk reaction to that question is that its purpose is to aid in solving problems and in creating desirable states of system performance. This perspective views systems thinking as being driven by a systemic type of conceptual framework that enables people to define problematic states and their causes. Systems thinking is also viewed as a form of reasoning with the capacity to reliably lead to all sorts of solutions and accommodations that would otherwise be less likely to be discovered by more conventional thought processes. Traditionally, even systems approaches to performance improvement tend to minimize the importance of action learning, knowledge, and the developmental need for increasing problem-solving capacity over time. Surely, both the “soft” systems methodologies developed by Ackoff (1974) and Churchman (1971) have action learning schemes baked into them, but they do not even acknowledge the

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important role of knowledge or conceptual modeling in their approaches. Their approaches are pragmatic, in the most general sense, but fail to explicitly account for the results of action learning that accrue over time—namely the development of knowledge. Even though performance improvement initiatives are rarely approached from a pure *tabula rasa* state, without specific *a priori* knowledge, of the system-in-focus, most systems methods emphasize understanding how the system has evolved over time, rather than how one's knowledge of the system has accumulated. In general, systems theories ignore epistemological considerations that acknowledge the relative role of action learning and knowledge development toward increasing the effectiveness of systems interventions. Often, in the course of human events, the primary role of reasoning is considered as being the sole basis of problem-solving effectiveness without regard for the explicit efforts to tap into knowledge. With the relatively recent advent of knowledge-intensive approaches, such as knowledge management, the role of knowledge is becoming more evident and explicit in managerial processes. Knowledge-intensive processes, such as those proposed by McElroy (2003) and Allee (2003) are becoming increasingly commonly used in organizations. In systems thinking the role of knowledge has largely been relegated to surfacing assumptions or what is often referred to as “knowledge elicitation.” Vennix and colleagues (1990) describe the knowledge elicitation problem as one of modeling facilitators knowing “how to obtain necessary knowledge from a group of people” (p. 194). Their knowledge elicitation approach involves the use of Delphi questionnaires, a workbook that allows participants to critique proposal models, and structured discussions. This approach is a very good example of the prevailing view that knowledge is “justified true belief” and can be treated separately from the perceptions, rules for action, and actual experiences of participants. By contrast, the philosophical approach known as *pragmatism* views knowledge as being much more deeply ground in action and human experience, and argues for a much more practical and comprehensive view of knowledge. This theme of philosophical pragmatism will serve as the centerpiece of this article in that it will serve as the foundation for a proposed pragmatic knowledge-intensive approach to systems thinking.

A PRAGMATIC VIEW OF KNOWLEDGE

Many of the systems that people interact with each day possess sufficient complexity, variety, and dynamism to render simple reasoning less important than past experiences, learning, and knowledge in understanding the potential of alternative policies for yielding desired performance states. In such situations, knowledge plays an increasingly important role. It is proposed in this article that developing high quality knowledge in relation to such systems is as important to effective systems interventions as is effectively using systems thinking itself. Here, effective intervention is activated by knowledge as much as it is through skill in applying systems thinking. Systems thinking and pragmatic knowledge-creating processes are both defined by their grounding in how things actually work in practice. In systems thinking, dynamic models of cause and effect are created to show how interactions among system elements produce emergent and unintended behaviors.

The grounding is found in measuring the actual performance patterns of the system and identifying the actual recurring interactions that occur among system elements.

Pragmatic knowledge-creating processes are grounded in the actions taken by “actors” in a system and the results that flow from these actions. To understand this perspective, it is necessary to appreciate the basic tenets of American Pragmatism as defined initially by Charles Sanders Peirce, and later by luminaries such as William James, John Dewey, and Josiah Royce. As defined in the pragmatic tradition of C. S. Peirce, knowledge is most often of the type that defines the causal relations that are manifest in the routine operations of the universe. The spirit of pragmatism, as defined by Peirce, is most succinctly captured in Peirce’s pragmatic maxim, “Consider what effects, that might conceivably have practical bearings, we conceive the object of our conception to have. Then, our conception of these effects in the whole of our conception of the object” (quoted in Potter, 1996, p. 94). This maxim was later clarified by Peirce’s popular protégé William James: “To attain perfect clearness in our thoughts of an object . . . we need only consider . . . what sensations we are to expect from it, and what reactions we must prepare. The ultimate test for us of what a truth means is indeed the conduct it dictates or inspires. But it inspires that conduct because it first foretells some particular turn to our experience which shall call for just that conduct from us” (quoted in Potter, 1996, p. 94). Pragmatism is concerned with actions, causes, and effects, in a similar way to how science conducts the process of experimentation.

Unsurprisingly, systems thinking is similarly concerned with defining systemic patterns of causal relationship. In effect, pragmatic knowledge serves as the basis for creating systemic understandings of how systems behave over time. The relationship between the philosophy of pragmatism and systems thinking is found embedded in the writings of systems thinkers, such as Ackoff, Argyris, Churchman, Mitroff, and others, yet it is rarely discussed explicitly. Another purpose of this article is to identify and describe the relationship between systems thinking, learning, and knowledge in general, and specifically to elucidate the link between pragmatic views of knowledge and applying systems thinking to the practical concerns of people.

Pragmatism is best known by its oft misunderstood rule-of-thumb “whatever works is true.” Peirce helped to establish the notion that *truth* is more reliably known by identifying those actions that are reliably effective at producing expected results, and inferring what this reflects about the system acted upon (Potter, 1996). This stands in bold contrast to the traditional philosophical approach that proposes that truth is best known through a rigorous logical process of reasoning by building on certain foundational assumptions or natural laws. Such a process proposes that if logical reasoning processes are used to discover what has been previously unknown—by building on what is thought to be known with certainty—then truth may be approximated. Pragmatism, as well as Karl Popper’s philosophy of *fallibilism*, argues that the emphasis of scientific investigation should be on not only proving hypotheses, but placing equal effort into disproving them. Single-minded efforts solely designed to just prove the correctness of hypotheses often produce erroneous conclusions about what is true. On the other hand, in pragmatism, what

works in practice is governed not solely by human perception or reasoning, but by certain universal laws of cause and effect that tend to be reliable in causing the same effects in response to like actions. If you toss a tennis ball into the air on Earth, its behavior will be highly predictable and reliable. This is because of the constant force of gravity that is influencing the ball to, at some point, return to Earth. Although interventions in social and organizational systems do not have such regularity, there are also underlying patterns that govern any system's behavior and how it will respond to human initiatives. Simply discovering *what works best* in interacting with a complex system is just the beginning of the process of creating pragmatic knowledge. The real work of pragmatic knowledge creation comes in the form of discovering why whatever works is able to be effective and to identify the mechanisms that enable this effectiveness to be realized. Unfortunately, the pragmatic maxim has been regularly misinterpreted as being a simplistic guide to action that indicates people should *only* seek to identify and do what works—rather than do what they *believe* should work. By focusing exclusively on the actions to be taken—and omitting the reasons why—enables people's beliefs to remain fixed, and misaligned with the way the world really works. In the long term, the only consequence of holding misaligned beliefs will be ineffectiveness in reaching desired states. Some scholars have proposed that this misunderstanding can be traced to William James' own failure to understand the teachings of his mentor Charles Peirce on this matter. Peirce offered a more complex explanation of a pragmatic view of learning from experience that offers a differing view of the significance of discovering effective actions—one that has direct ramifications for systems thinking. In essence, Peirce argued that discovering what practices work reliably well is most useful because it offers feedback on the validity of our beliefs about what works that is grounded in reality. Peirce observed that action, without doubt, is instrumental in thinking processes—both in the sense that thinking is a form of action and the sense that thinking normally results in action. Action is a basis for thought, but its primary purpose is to establish a firmly held belief—a rule for action—and ultimately a habitual way of thinking about causal relations in the world. Therefore, if there is indeed a disconnect between what one believes will work in practice, and what tends to work reliably well, then it is one's beliefs that are in need of revision. Peirce's consistent focus was laser-like in its direction toward focusing on the need for people to modify their own beliefs to more accurately know how things actually work in practice. Yet, the willingness to doubt the validity of one's beliefs is a challenge that most people are consistently adept at avoiding. Throughout his career Peirce maintained that “doubting is not as easy as lying.” By contrast, if someone were capable of being unerringly effective in always taking actions that produce the expected results, then it could be deduced that their beliefs are true.

So, how do people's beliefs become so askew? In the Peircian view, there are two major explanations. First, when people fail to engage in meaningful doubt and skepticism, their beliefs about how and why things work as they do in practice tend to become *fixated*. According to this view, beliefs are most valuable when they are viewed as being in a continuous state of improvement, capable of adapting to fit with new signs or evidence about how things really work in practice. True doubt

is neither a comfortable nor easy state for most people to maintain. Ironically, one may deduce through the actions of large numbers of people that their tendencies are to become stuck in sub-optimal states of effectiveness rather than embark on the journey of aligning their beliefs about how things work with the feedback from the effects of their actions. The second reason that people tend to become fixated in their beliefs, noted Peirce, is that people are prone to discount the validity of the opinions of others—easily finding the faults in other people's beliefs, but remaining assured in the validity of their own reasoning. This seems akin to what Argyris (1990) described as being a *defensive routine*. The combined effects of these two types of inclinations is to reinforce people in steadfastly holding onto beliefs that are ineffective, and being more than willing to attribute the failure of their actions to the influence of exogenous factors. The frequency with which people adopt simplistic notions of reality that satisfy their skepticism about how and why things work as they do has the unintended effect of dulling their willingness to inquire into the precise nature of cause and effect relations as they relate to practical concerns.

SYSTEMATICALLY EXPLORING CAUSALITY

In order to come to a reasonable understanding of the way in which one's beliefs propel their actions it is greatly helpful to be willing to view the world from a causal perspective. Such a view has two distinguishing features. First, the world is seen through a lens that casts outcomes as being the result of a continual process of subtle evolution, rather than a series of unrelated discrete events. In this process, the actors in a system play an instrument role in the evolution of a system by making decisions, taking actions, noting effects, and integrating the significance of these effects into their own personal "theories of action." Second, this evolution is viewed as being caused by the interactions dynamic and self-organizing factors that unfold over time. In the narrow sense, taking such a causal view of the world means seeing that systems evolve as a result of interactions with other systems, their own subsystems, and the human actors who interact with them and that performance dynamics are caused by these interactions. In the broader view, actors begin to become conscious of their own role in precipitating this process of unfolding by acknowledging how their own belief systems influence their perceptions, decisions, and actions as they co-create what is to become in a dynamic interplay with other actors and systems. Ideally, as such actors mature in terms of their depth of experience in interacting with complex systems, they become more responsible for their actions, aware of the influence of their beliefs on their actions, and more reflective in heeding the signs provided by performance feedback about the effectiveness of their actions. In systems thinking, such activities are often reserved for the modeling process, whereas in pragmatic knowledge-creating processes they are viewed as being part of everyday work experience.

It should come as no surprise that such fundamental precepts from pragmatism have quietly crept into the systems thinking literature. In several forms of systems thinking, such as "soft systems thinking" and system dynamics, an important modeling element of identifying a system's underlying structure involves either causal

mapping or causal loop diagramming. Both approaches are designed to capture underlying recurring causal patterns that give rise to characteristic behaviors that define the system itself, and to relate them to mental models. Such modeling efforts are typically of a reiterative nature and seek to align the system's causal structure with its pattern of behavior over time. Well-known advocates for the value of systems thinking, such as Peter Senge (1990) and John Sterman (2000), suggest that the principal value of such modeling processes is the potential to help enrich mental models. This is entirely a pragmatic approach to knowledge-creation that is similar to what Peirce argued for in the late 1800s. It is pragmatic in the following senses: (1) it links performance feedback to a reference mode of behavior, which in pragmatism is the expected result; (2) mismatches are traced to the actions and decisions of policy makers; and (3) the ineffective decisions and actions made by policymakers are attributed to incomplete or incoherent mental models (systems of beliefs). This is all quite pragmatic in the sense that what is true about the efficacy of actions is deduced by grounding such assessments in performance effectiveness. What is different about systems thinking from the philosophy of pragmatism is that systems thinking provides explanations of the reasons for unintended consequences by using the modeling process to transform the "black box" of any system's internal operations into a transparent "white box" where causal relations are identified. On the other hand, in pragmatism, there is little effort made to uncover the contents of the system's underlying structures, and instead the focus is placed on analyzing the bases for perceptions, choice of decision rules, expectations, and weightings of potentially usable actions strategies all found in human knowledge. In this pragmatic view, the contents of the system are regarded as being virtually irrelevant, whereas what is of paramount interest is discovering the reasons why the knowledge and beliefs that govern one's actions are ineffective. The discovery of pragmatic notions contained within systems approaches is not merely coincidental.

A brief study of the lineage of pragmatism reveals a direct line from Charles Peirce to two of the great contemporary systems thinkers, Russell Ackoff and C. West Churchman. A historical analysis reveals that Peirce's primary disciples were John Dewey, William James, and the religious scholar Josiah Royce. James was the mentor of the famed philosopher Edgar Singer at the University of Pennsylvania where he was mentor to both Ackoff and Churchman. Ackoff has also acknowledged meeting periodically with Dewey until the time of his passing. Harvard philosophy professor Hilary Putnam noted the connection between James, Singer, and Churchman in describing his own undergraduate education at the University of Pennsylvania, "That education took place at the University of Pennsylvania, and one of James's students, A. E. Singer Jr., was a famous professor in that Department for many years. Although Singer had retired when I entered the university, he was still living in Philadelphia, and some senior members of the Department visited him regularly. One of those members, C. West Churchman, wrote the following four principles, which he attributed to Singer on the blackboard:

- 1) Knowledge of facts presupposes knowledge of theories;
- 2) Knowledge of theories presupposes knowledge of facts;

- 3) Knowledge of facts presupposes knowledge of values;
- 4) Knowledge of values presupposes knowledge of facts.

And I am sure that Singer's teacher, William James, would have agreed!" (Putman, 1995, pp. 13–14).

In a similar manner, it can be argued that much of the work done by Argyris, as well as Argyris and Schon, involving double-loop learning is done in the pragmatic vein, yet it oversimplifies and omits many of the principles that Peirce deemed as being critical to the practice of pragmatism. Argyris' line of inquiry is especially significant because it appears to have heavily influenced Peter Senge (1990) in constructing several of the "Five Disciplines" in his now classic book, *The Fifth Discipline*. The link between systems thinking and pragmatism is implicit in the Fifth Discipline, yet unmistakable. Senge's discovery that the processes of systems thinking, learning through experience, (action learning) enriching mental models, and surfacing assumptions about causality are intimately related was a major breakthrough in systems thinking, but unfortunately, does not include the critical linchpin—namely, the role of knowledge and knowledge-creating activities. Knowledge is the central element that links together action learning, systems thinking, beliefs, and the importance of reviewing feedback received from the effects of prior actions into a cohesive whole. What is the role of knowledge in the pragmatist's scheme and how does it relate to systems thinking?

PRAGMATIC EPISTEMOLOGY

According to *Webster's Universal College Dictionary*, epistemology is "a branch of philosophy that investigates the origins, nature, methods, and limits of human knowledge." In the pragmatic tradition, knowledge is viewed as being formed on the basis of feedback regarding effectiveness of those prior actions taken. This view is based on the notion that it is one's beliefs and knowledge that ultimately give rise to one's expectations about the effects of one's actions. The pragmatic view is that if one's beliefs are true and knowledge reliably valid then all of the results of one's actions will consistently match expected results. In other words, if one has the capacity for being able to consistently create results that match one's expected results, that it is fair to deduce that those beliefs that are relevant to the performance are true, and the knowledge invoked is valid. Does this mean that our beliefs must be infallible to be true? The short answer is "No." In the pragmatic tradition, knowledge is rarely ever completely true. Instead, knowledge may still be useful, even when it is not always true. In the most general sense, it is reasonable to assert that all knowledge is wrong, but some knowledge is useful. For practical purposes, it is more important that any knowledge in question be trustworthy, reliable, and efficacious than that it be true. In fact, there are artificial intelligence systems that function in corporations today, based on these pragmatic ideas that what organizations really need is practical information.

What might a pragmatic knowledge-processing system look like and how might it operate? A branch of the field of artificial intelligence known as *Autognomics*, has addressed this question and designed technologies that operate according to

pragmatic principles. This perspective views knowledge as a rule-based system for choosing one's purposeful actions in certain perceived contexts, in light of a specific desired outcome or state that is sought. According to this view, knowledge is composed of situation-specific sets of algorithms and heuristics for taking effective action that are dependent on how a situation is interpreted and the goal that is being pursued. According to this view, knowledge is an individual's inventory of these bundles of rules, habitual ways of perceiving certain situations, and desired outcomes. In the language of pragmatism, these bundles are termed *Acts*, so knowledge is one's personal inventory of potentially useful acts that can be called on in a given situation. This pool of acts ranges from those that are frequently used about which much is known and trustworthiness has been proven, to other acts about which little is known or ones that may have proven to be ineffective in producing desired results. Over time, and with learning through experience, acts become modified, categorized in terms of reliability, and placed in the proper location in a hierarchy of utility based on past experiences. Notably, the relative position of acts in this hierarchy is determined not by human thoughts about their intrinsic merit, but rather by their efficacy in praxis. Argyris (1993) has observed that "Actionable knowledge is not only relevant to the world of practice; it is the knowledge that people use to create that world" (p. 1). The traditional view is that "knowledge is power," whereas Webster's dictionary defines knowledge in a more practical way as being "the ability to do or act." Knowledge can empower a person or a group to act in ways that are more reliably effective at attaining valued results than if they act in less informed ways. All systems exist to fulfill their identity through their purposeful actions over time. Knowledge's ultimate purpose is to facilitate the realization of a person or system's identity by helping them to align their beliefs about how things work with how the world really operates. Knowledge not only guides our future actions, but it serves as a reminder of what has worked effectively, in the past, so as to inform our beliefs about how and why things work as they do in practice. The process of forming new knowledge or modifying existing knowledge is essentially a self-organizing one that operates within a closed or bounded system. Any system creates a closed system by choosing which elements of its environment it will acknowledge and engage. Such interactions between any system and its environment are grounded in this closed network of relations and have the effect of both reflecting and shaping the system's own identity over time. Any system's environment impacts it through various perturbations of the relations with the system, over time. Naturally, the system's response to these perturbations is to attempt to mitigate them by acting, either inwardly (i.e., changing the system itself) or outwardly (i.e., changing the environment). Although in practice some of these actions will turn out to be successful in mitigating these perturbations, others will not. Most complex adaptive systems have the built-in capacity to acknowledge these actual results and seek to perform those "acts" that have demonstrated their success, in the past, when similar situations arise. Over time, the cumulative effect of achieving these successes is that it elevates these acts of knowledge to a relatively more visible position within the pool of potentially usable acts. This genre of adaptive change seen in the system, then, is one based on "learning" that certain acts of knowledge used can be potentially performed again, in the future, as a way

to deal with additional perturbations within the system's enacted environment. In other words, a complex adaptive system will learn through experience by adjusting itself, in terms of both inward and outward acts—to create knowledge from experience. Not surprisingly, this is a natural process for humans, yet the forces of philosophical rationalism, mechanical worldviews, and simple near-sighted expediency have somehow conspired to cast this form of knowledge in an unfavorable light. The ultimate irony is that pragmatic knowledge-creating activities have often become viewed as impractical, or anti-pragmatic, for addressing the concerns of modern organizations. In point of fact, this type of knowledge is potentially far more practical and effective than other forms of “knowledge” that are really more like context-bound information. Let us take a look at what pragmatic knowledge really is and how it works.

ELEMENTS OF PRAGMATIC KNOWLEDGE

At its essence, knowledge is composed of and grounded solely in *potentially usable* acts and perceived symbols, in the environment, that refer to them. Please note that the term “act” is used here as a noun, not a verb. People's ability to effectively employ acts is guided by applying a particular *rule* to a recognized situation—under particular *conditions*—with a particular *expected result* that arises as a consequence of having acted. The term *potential act* indicates that the system “knows” that if such conditions were to occur again, in the future, a program of action guided by that rule would produce that anticipated result with some measure of reliability. When we employ a particular act in a recognized situation and its use becomes so highly effective in yielding the desired results, then our confidence in our own ability to obtain success grows and becomes virtually taken for granted. In other words, we believe in the efficacy of our approach in a way that becomes habit. If the anticipated reliability of an act is high, then the potential act engenders a *belief*. Beliefs are simply convictions about the likelihood that we will achieve a desired result that is so significant that it becomes a basis on which one is prepared to act—even when the consequences of failure are more than trivial. Not all points of view are beliefs because in order for a position that is held to reach the threshold of being a belief one must be prepared to act on it.

Whereas the opinions we hold on matters of interest, say in politics, religion, economics, and many other subjects, may reflect one's points of view on matters that do not involve a direct personal stake. For example, many of us may hold political opinions about corporate ethics and openness, but few of us are willing to act on these opinions. However, if one is willing to invest a large portion of their personal savings by purchasing the common stock of a business that is viewed as being operated in an ethical and open manner, then there is evidence of the presence of a firm belief because you have acted to purchase the stock and risk your savings. Conversely, if a potential act is considered to be unreliable, then it is likely to precipitate an irritating feeling of “doubt” about the efficacy of that act to produce the envisioned outcome.

It may be helpful to view the relationship between belief, doubt, and inquiry in a dynamic way in order to more fully grasp their relationship to each other.

Believing in the efficacy of any act to bring about the desired result has the dual effect of putting doubt to rest and begins to reinforce the belief in a way that, over time, will lead to forming a habit. Believing in an act also brings inquiry to rest. Holding doubts serves to initiate a process of inquiry that is designed to discover either new acts or new information that may prove to be helpful in modifying existing acts.

When we examine the respective roles of belief, doubt, and inquiry in complex adaptive systems we learn that they are essential processes for helping to maintain and express any system's identity. The natural programming of any complex adaptive system is designed in a binary way, such that the system works in a way where establishment of belief is relentlessly pursued, and seeks to avoid the experience of doubts by using inquiry to settle belief. Yet, despite this aversion to doubt, it is a necessary experience in order to trigger a search for new information that can improve existing beliefs or replace them with more effective ones. Peirce considered the principle of being willing to experience the discomfort of doubt to be so essential that he considered it the primary motivating force behind learning. For some people, the experience of doubt is so disconcerting that they orient their lives around strategies for avoiding the nagging sense of distress that often accompanies the experience of doubt. He called this feeling, the "irritant of doubt" to convey the fundamental organic nature of this driving force in human experience. Peirce observed, "Belief is not a momentary mode of consciousness; it is a habit of mind essentially enduring for some time, and mostly (at least) unconscious; and like other habits, it is (until it meets with some surprise that begins its dissolution) perfectly self-satisfied. Doubt is of an altogether contrary genus. It is not a habit, but the privation of a habit. Now a privation of a habit, in order to be anything at all, must be a condition of erratic activity that in some way must get superceded by habit" (Weiner, p. 189). Belief, doubt, and inquiry are three essential processes that lead to the creation, improvement, and maintenance of knowledge. Let us examine how these processes influence the three basic elements of knowledge, namely case, rule, and expected result.

THE STRUCTURE OF KNOWLEDGE ACTS

As the concept of an *act* has been examined so far at the level of generality, we cannot proceed to understand its relevance to systems thinking without adding more detail about the notion of the act itself. Much like an atom is composed of protons, electrons, and neutrons, an act is a similar type of triadic (three-way) relation between a *Case*, a *Rule*, and a *Result*. A *Case* is the perceived situation that enables the act to be performed. For example, in order for a manager to reinforce an employee's meritorious behavior, there must first be a situation in which the manager perceives that the employee has in fact acted meritoriously in some regard. The *Rule* names the law governing the performance of the act. For inward acts of thought, this law can be thought of as a general principle or concept that relates the *Case* and *Result*, such as the "Law of Addition" relating numbers and a mathematical sign ($1 + 1$) to 2. It is considered a law because it is a generality that covers an inexhaustible set of actual instances. For outward acts,

this law governs a class of possible physical actions at some level of abstraction. For example, at some level of understanding, the principle of “positively reinforced meritorious employee behavior” is an act that can be specifically accomplished in an infinite number of ways at greater levels of detail (e.g., providing recognition, offering promotion, bestowing financial awards, etc.) The Result expresses the anticipated consequences of having acted at an earlier point in time, so that it portrays the image of an *expected* result. In knowledge, the Case and Result of a particular potential act express hypothetical conditions that the system can later recognize as actually being present at some particular time. More specifically, these potential situations refer to the Rules of other acts that can be recognized or invoked according to their own respective potential acts—ones that also are found in the pool of knowledge. Accordingly, potential acts in knowledge are arranged hierarchically, starting at the base with the simplest ones and ending at the top with the most complex or abstract one. Many times, the more abstract of those potential acts tend to often refer, in their Cases and Results, to the Rules found in many of the more elementary acts within the system.

By this definition, acts of knowledge can be both inwardly focused in their intent, as well as being designed to fulfill some “outer” purpose relating to the environment. Inward acts are those that are designed to effect changes within the system itself and exert internal pressure for the system to evolve in a particular direction. Some outward acts can be understood as being primarily intended to effect changes in the way a system engages its environment—this is what we might typically think of as “overt action.” Other outward acts may have more of an inquiring purpose and proceed to conduct various “experiments” on the environment, to determine if those act are successful, then they indicate the presence or absence of a particularly noteworthy condition embedded in the environment. Often, such acts can be thought of as “perceptually focused” acts in that they are concerned with increasing the capacity of future acts to respond to specific potential states that could be found in the environment. However, acts of any type may serve to orient a system’s future actions merely by processing the feedback from the success or failure of previous actions. Such prior overt actions taken in relation to the perceived environment often set the stage for future actions by defining the context of how various symbols and situations will be perceived. According to this view, “thought” or “cognition” are interpreted simply as being inward acts that have the effect of changing a person’s state of mind or the level of awareness in a system. Peirce identified three fundamental types of inward acts, corresponding to changes in the state of mind regarding: (1) what actually is the present situation, (2) what is anticipated to occur in the future, and (3) changes in knowledge itself.

A PRAGMATIC VIEW OF COGNITION

Our search for the links between systems thinking and pragmatic knowledge are moving forward in a deliberate way, but we have yet to reach our destination because we have yet to deal with the role of cognition in the pragmatic tradition. In systems thinking, the concept of the the mental model is ubiquitous, yet there is no analog to it in pragmatic views of cognition. In pragmatism there is no specific

construct that is parallel to the image representations of the structure of the enclosing environment known as mental models. Do mental models really exist within the people's minds? There is little doubt that there are simplified representations of the perceived outer world embedded within people's minds that fairly deserve to be called "knowledge." Yet, the obvious question immediately arises: Is its presence not simply additional supporting evidence for the insufficiency of our current definition of knowledge? To gain insight into this question we must inquire into the meaning of the word *representation*, as it relates to mental models. Maturana and Varela (1987) propose that autopoietic systems do not process information about the external world by allowing it to "flow" into the system to inform any sort of process that is designed to produce any sort of representations of a particular perceived world. Rather, such self-organizing systems create their own representations based on existing information it already possesses—namely, its acts of knowledge that serve as the basis for the ways it chooses to perform. More simply, the term "representation" takes on a different meaning—one directed toward a process of creating an internally constructed relationship between (1) that artifact that is functioning to represent some entity (the "sign") and (2) a complex of acts by which something, which is seen as being "out there in the word" is ultimately able to be recognized as "the object" of one's attention. Philosophically, this stance represents a significant departure from conventional systems theories. In this view, there is no necessary objective correspondence required between any object being represented and any "real" object that might actually exist—other than the fact that the person or the system finds it useful to believe that such a correspondence exists for the purpose of managing its actions. Whether mental models actually exist, per se, or perform a definitive role in knowledge-creating processes is a matter of speculation. However, the more significant point is that, regardless of how we label it, there is a paramount need for aligning one's worldview and beliefs with the manner in which the world actually works.

Knowledge of what works most effectively in practice and why it tends to work may be gained through experience, and is, by all accounts, instrumental in governing the potential effectiveness of one's future actions taken in complex systems. The notion that knowledge, in general, is formed and confirmed only on the basis of experienced acts means that each potential knowledge act is always in a transitional state of validation, one that is subject to further confirmation or refutation during each new interval of experience. In the hierarchy of acts that constitute knowledge, there will be some acts that have been shown to yield the expected results, but there will also be acts with unproven and unknown potential for attaining desired results. Such a set of acts containing proven or validated acts exists primarily as an ideal rather than a reality. The extent to which a complex adaptive systems model of knowledge-creation can be usefully applied to organizations is unknown. Individuals and some groups operate as complex adaptive systems, but then again, the managers of many organizations aspire to operate them in machine-like fashion to achieve perceived efficiencies. Admittedly, there are important differences between systems whose components are autonomous—as are individuals making up an organization—and systems whose components are not autonomous—for example, the organs of the human body. For example, in the human anatomy, there

are certain key organs, such as the brain—where adaptive change is largely concentrated leading to highly coherent and interrelated adaptive activity, what we know as “mind” and “thought.” Processes of adaptation in organizations, however, are much more diffuse and incoherent, as significant changes can occur in each individual as well as in the relationships between individuals, groups of individuals, and even technology throughout an organization. Although such a concept of knowledge is necessary to provide a clear view of how systems thinking can be enabled through the application of knowledge, alone it is insufficient.

SYSTEMS THINKING AND KNOWLEDGE

Although great strides have been made in systems thinking over the past two decades, in describing links between mental models, and systems thinking, the role of knowledge has been largely omitted. The reasons for this are both simple and complex. A simple explanation is that systems thinking and mental models have been linked for some 40 years in system dynamics. For example, Senge (1990) notes “Failure to appreciate mental models has undermined many efforts to foster systems thinking.” Sterman (2000) writes, “The concept of mental model has been central to system dynamics from the beginning of the field” (p. 16). Forrester (1961) stresses that all decisions are based on models, usually mental models. Most people do not sense the pervasive, yet subtle, influence of mental models on how we make decisions, instead we mistakenly believe that we are perceiving the world transparently. On the contrary, our world is actively constructed (modeled) by our senses and brain” (pp. 16–17). Mental models are explicitly linked to policy formulation in system dynamics, yet most discussions of knowledge are limited to the function of knowledge elicitation. Vasquez, Liz, and Varacil (1996) note that three kinds of knowledge are involved in building system dynamics models: (1) structural knowledge, (2) quantitative knowledge, and (3) operational knowledge. Structural knowledge is knowledge contained in the mental models of modelers about the underlying patterns of cause and effect in a system. Quantitative knowledge focuses on understanding how performance and other objective measures vary over time. Operational knowledge involves the skills required for modeling and understanding systems theories. Again, there is little attention devoted to how knowledge is created in modeling processes, and the types of knowledge discussed are not clearly rooted in action, as are done in the traditions of pragmatism. However, there are other systems approaches that are more pragmatic in nature than system dynamics.

CAUSAL RELATIONS IN SYSTEMS THINKING AND KNOWLEDGE PROCESSES

One of the significant contributions of systems theory is the idea of the need to understand the interactions among a system’s elements and their influence on each other, in terms of cause and effect, to understand its behavior over time. Several systems approaches, such as Ackoff’s Interactive Planning, Beer’s Viable System Model, Checkland’s (1981) “Soft” Systems Methodology, Churchman’s (1971) Inquiring System, and Eden’s (1989) Cognitive Mapping and SODA, place particular

emphasis on grounding systemic understandings in experience and identifying patterns of the causal relations that are capable of altering the system's behavior in some way. In a similar vein, pragmatic knowledge-creating processes seek to identify cause-effect linkages by relating acts, and beliefs, with feedback from the results of actions taken.

In systems thinking, many of the methods cited focus on developing a conceptual model of a system's boundaries, causal relations among elements, and specifying how such interactions effect a systems behavior or its capacity to fulfill its purpose. In the pragmatic knowledge-creating processes, described earlier, there are similar efforts made to identify patterns of cause and effect between using certain acts to achieve a specific result and actual performance. However, the end purpose is quite different than that which is found in system thinking methods. Pragmatic knowledge approaches use the extent of match between expectations and performance to validate the utility of acts. Systems approaches, on the other hand, seek to determine whether the correct policies have been formulated or to know if the system has been properly designed. In both pragmatic and systems approaches, there are ongoing efforts to align cognitive beliefs and intervention strategies with the desired system behaviors. Clearly, developing causal theories that relate structures to performance is central to systems modeling processes and to knowledge-creating processes linked with action learning. In pragmatic knowledge-creating processes, the implicit goal is to ultimately evolve a system of beliefs that will reliably lead to the construction of effective acts.

As this point, it is helpful to review the similarities between systems modeling approaches and pragmatic knowledge creation. For reference purposes, the systems thinking modeling approach, advocated by Senge (1990) will be examined. In this approach to system modeling, system boundaries are defined through including only those elements in the model that are causal elements capable of altering the performance of other systems elements in discernable ways. Causal relations are mapped and feedback loops are identified with polarities of either a positive or negative nature. Time delays are also shown in such models by indicating a // mark on the causal arrows. Most importantly, feedback loops are analyzed to determine how they cause the patterns of behavior-over-time of the system. A notion that is essential to this variety of systems thinking is that feedback loops and interactions among feedback loops are responsible for the system's performance dynamics over time. However, this is an oversimplification of this systems thinking paradigm—one that omits an essential point. A system's performance dynamics are not solely seen as being a function of its systemic structure, but rather a function of the interaction between the policy inputs of any system and its systemic structure. Policy inputs can take many forms, but typically are stated as strategies in organizations, such as the policy of setting prices at a level that is ten percent below our nearest competitor's latest price or twenty percent above our unit cost—then choosing the one that yields the greatest profit margin per unit.

In this method, the match/mismatch between effects of actions taken and expected results typically will lead modelers to depict such cause-effect patterns in the model. The goal of the modeling process is to iteratively and over time move toward developing models of greater validity that serve as an ever more accurate

mirror of reality. In systems thinking, the modeling process is viewed as being a vehicle for surfacing or eliciting the mental models of those policymakers who are concerned with the system's performance. The prevailing view is that differences between ideal and performance patterns reflect the existence of faulty policies that are caused by incoherencies in the mental models of policymakers. Another test of the coherency of mental models, advocated by Senge, is to subject the causal claims of policymakers to the scrutiny of groups with similar interests, or what Peirce refers to as a "community of committed inquirers" (Wiener, p. 83). In organizational contexts, these are colleagues and people who are doing the same kinds of work, not external experts or consultants. Computational technologies, such as simulation, can also be used to validate the efficacy of performance claims. In Senge's approach to systems thinking, it appears that a primary goal is to raise the awareness of policymakers to flaws in their mental models by pointing out logical inconsistencies that appear in model structure and performance pairings. The basis for making such assertions is that only certain kinds of structures have the capacity to cause certain performance patterns. For example, a reinforcing or positive feedback loop can only cause exponential growth or decay. By contrast, balancing or negative feedback loops can only cause oscillating performance patterns. These syllogisms provide logical limits on the types of behavior that can be attributed to certain feedback loop causes. When a mismatch is brought to light, it provides a concrete basis for challenging the validity for the mental models of policymakers. In a similar vein, the consensus among a community of committed inquirers can also provide a tangible basis for questioning one's knowledge claims about structure-performance arguments.

In the pragmatic knowledge approach, there is a similar goal of identifying mismatches between expected results and actual results, but the reasoning of what to do next differs markedly. In pragmatic knowledge-centric approaches, feedback on differences between results and expected results has two impacts, one short term and one long term. The short-term effect of such feedback is to either confirm the efficaciousness of certain act's or call it into question. When the efficacy of an act is doubted it may call into question the choice of act, the act's relative weighting in the hierarchy of acts, the acts reliability, as well as the elements of the act itself. The act's elements of case, rule, and expected result may be questioned in the following ways—were the symbols that define the situation perceived and interpreted correctly? The rules for action are the core of any act. The rules may be faulty in that they are not aligned with the expected results in that they may not reliably lead to the desired outcome. The long-term effect is that the underlying ideas used to construct acts may be faulty in some respect—such as, things may have changed in how things work, yet beliefs may not reflect those changes. The literature of systems thinking and organizational learning, such as Argyris (1993), proposes that through processes, such as double-loop learning, that mismatches between performance expectations and results directly cause feedback, to belief systems that can produce adjustments in mental models or assumptions about how and why things work as they do. Argyris attributes people's failure to change their mental models in response to disconfirming evidence of performance ineffectiveness as being a sign of defensive routines in action. An alternate explanation is that knowledge

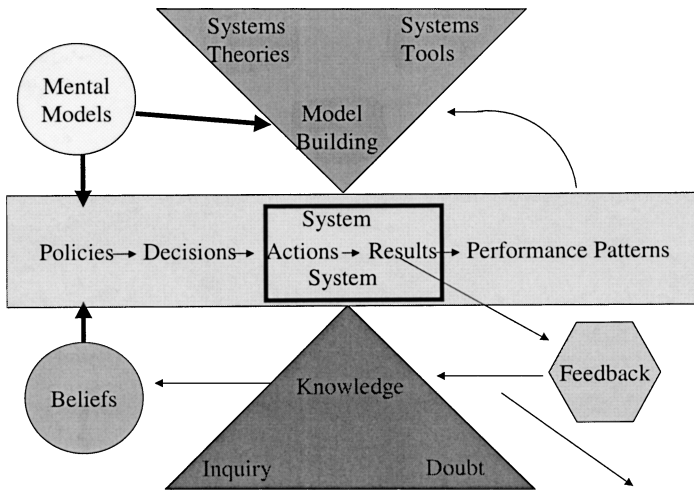


Figure 1. Knowledge Intensive Systems Thinking (KIST) Model.

serves to mediate between beliefs and performance feedback. As mentioned earlier, many beliefs are focused on convictions that certain acts will reliably produce expected results. In this light, the notion that changing one's beliefs, as a function of receiving performance feedback, seems unrealistic, and it is more likely that the critical leverage point is to be found in modifying knowledge. Essentially, knowledge development and creation is a cybernetic process predicated on the assumption of having reasonable performance expectations. One of the most critical areas of doubt involves questioning the rationality of performance expectations. This brief review of systems thinking methods and pragmatic knowledge-creating processes suggests that both are concerned with using feedback from performance results to ground future beliefs and expectations. The KIST model (Figure 1) offers a knowledge-intensive approach to systems modeling. Through the use of KIST, it becomes possible to combine these two approaches to increase the potential effectiveness of the practice of systems thinking? On the surface, it appears that these two approaches are synergistic. Systems modeling techniques tend to discover answers to questions of related concern to those who are interested in the pragmatics of knowledge creation. How might they be integrated to work as a single process? The proposed model is a first effort to make systems thinking and attendant interventions more knowledge-centric.

The role of knowledge in systems modeling has previously been addressed by Vennix et al. (1990); however his focus is on defining methods for use in eliciting existing knowledge from groups, rather than to propose a theory of knowledge-creation that plays an integral part of the modeling process. One way to think of how such an approach as KIST works is to view system modeling as being a top-down effort to capture the underlying structure of a system, and to envision the knowledge-creation process as being a bottom-up initiative designed to capture the perturbations of how a system responds to various knowledge-based actions

that have been previously taken. Over time, and through iteration, a pragmatic knowledge-creation system records the results obtained by using specific acts.

Systems thinking and modeling approaches often ignore the semiotic interpretations of how a system or situation may be variously interpreted. One exception to this is Checkland's SSM as it tends to focus on drawing out how stakeholders perceive a system. Over time, a knowledge base can aggregate many incidents of specific combinations of cases, perceptions, rules invoked, expected results, and results. Unlike a model that is based on aggregate or averaged data, the knowledge base provides a much richer profile based on actual experiences. Both knowledge acts and systems models can be useful for informing policymakers of ways to formulate improved policies—so both should be made available during the policy formulation process. Knowledge, beliefs, and mental models all influence each other, so they should all be brought to bear on each other prior to the policy formulation process. Although there is no certain prescribed method to achieve this confluence of knowledge, model-based insights, and mental models, there are some rules of thumb offered to guide praxis. First, the acts that emerge as being promising for their potential to be trustworthy in effectively achieving expected results are simply to be viewed, initially, as being knowledge claims—not truth. Knowledge claims are forms of non-validated knowledge, as distinguished from invalidated knowledge—that is, knowledge that has been proven to be unreliable in producing desired results. Non-validated knowledge has not yet been fully scrutinized to completely assess its potential efficacy. According to Peirce, the best way to appraise the efficacy of knowledge is to submit it to a community of committed inquirers for review. Such a community is a group of people, usually practitioners, who are dedicated to both learning and practicing within some specific domain of practice. Knowledge claims often take the form of being causal claims. That is, if I do "A," then it will cause "B" to happen. Thus, modeling efforts should commence with a systematic assessment of the causal claims and acts contained in both personal and common knowledge.

Second, model-building efforts have great potential to serve pragmatic processes of inquiry. That is, when the irritation of doubt arises as to the efficacy of certain acts of knowledge, inquiry becomes instrumental in seeking information that may potentially shed light on beliefs about how and why things work as they do. In many cases, acts are incorrectly constructed because the underlying beliefs about how and why things work as they do in practice are incomplete or distorted. Information acquired through modeling is not knowledge, *per se*, but it can be useful information that provides a larger context for more precisely designing acts to be aligned with the environment. Finally, policy-making efforts must in some way reconcile the differences between model-based insights and knowledge gained through experience. Both of these provide potentially valuable, but different, insights into the causal nature of complex systems. Here, policy and strategy-formulating processes are often tasked with integrating disparate ideas into a coherent guide to action. Models only reflect a modeler's beliefs about the underlying structures of how systems behave over time, yet models remain largely the result of impressions and mental models. On the other hand, pragmatic knowledge is grounded in actual experience, although it also contains a significant

element of subjectivity as well. In pragmatism, the process of identifying the acts that work reliably well in practice is merely a reflection of a different view of the same underlying causal structure of the same systems that modelers are seeking to understand. The central task of policymakers, then, is to use modeling-based insights to inform knowledge-creating processes in order to formulate better policies. It would appear that many of the great systems theorists were going in the right direction by trying to combine action learning with systems methodologies. However, the missing link, so to speak, would appear to be the important role played by pragmatic knowledge-creating processes. In conclusion, I wish to call the attention of systems theorists to the emerging task of designing a next generation of pragmatic knowledge-intensive systems methodologies.

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