Designing Knowledge Creating Processes

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Introduction

What causes new knowledge to be created in organizations? How can knowledge-creating processes be enabled? While numerous popular books and gurus champion the value of sharing existing knowledge and importing new knowledge into organizations, potential answers to these questions are much more elusive.

For example, one popular approach to knowledge creation proposed by Nonaka and Takeuchi [1] focuses on the process of converting tacit knowledge into explicit or codified knowledge. While this is a useful and necessary function in the development of new knowledge, it represents a small, and arguably less than significant part of the total process of knowledge creation. Though such well intended authors may try to reduce knowledge creating processes to the proverbial "three easy steps", we view the knowledge creating process as stemming from a more complex developmental process than is usually explained in the popular literature on the subject. This article explores several key concepts relevant to knowledge creating processes, including: (1) the relationship between organizational identity and knowledge creation, (2) the process of creating new knowledge through logical inference, and (3) the critical role of rule-based acts in improving organizational performance.

Knowledge creating processes are the single most critical value-adding processes in an organization. This article adopts a perspective where knowledge creation is seen as being a dynamic process of development that evolves over time. We will use a conceptual framework known as the Knowledge Life Cycle (KLC) model [2] [3] [4] to serve as the backdrop for our model of knowledge creation. The KLC model depicts knowledge as evolving, over periods of time, from unproven knowledge claims into codified validated knowledge. (Figure One) When knowledge is validated by a community of committed inquirers, the opinions they express attest to the reliability and effectiveness of validated knowledge in producing desired results.

Knowledge Life Cycle Model

According to the KLC model, organizational knowledge creation is an evolutionary process that occurs within a larger process of collective inferential reasoning in organizations. More simply, knowledge creation is the result of

efforts by agents, acting either as individuals, or collaboratively, as an element of a system, to make sense of their environment. Such sense-making efforts are intended to enable them to take progressively more effective action -from the agent's point of view- in that environment. Ultimately, the purpose of knowledge creating processes is to express the organization's or system's identity through taking new or more reliable actions. In other words, *knowledge is not created to inform just any or all conceivable action, but rather is focused on those actions that are of value to a particular and unique organization*. Identity, in this view, is the *raison d'etre* of a number of generative organizational

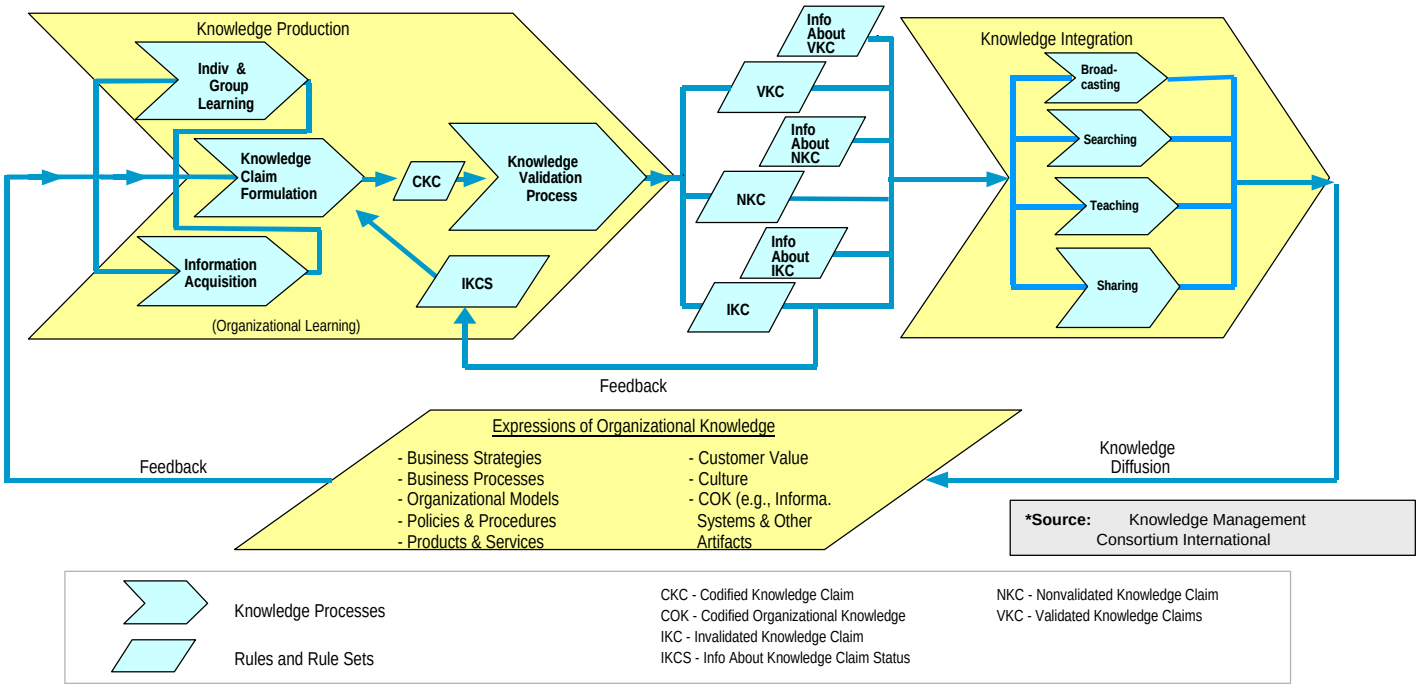

Figure One -- The Knowledge Life Cycle Model (as modified by Cavaleri and McElroy 1999)

processes in which individual agents seek to self-organize into various emergent collective forms, such as communities of practice. Identity functions as an organization's final point of reference by which all shared values are determined. Since the role of organizational identity in relation to knowledge creating processes has not been widely discussed within the knowledge management field, it is important to examine this feature of organizational functioning more closely.

Organizational Identity

Organizational knowledge creation is an evolutionary process that occurs within a larger process of collective inferential reasoning in organizations. In other words, agents in organizations act by applying rules to perceived sets of circumstances, so as to attain desired outcomes. Reasoning, in the form of deduction, induction, and abduction, plays a critical role in determining how the agent will seek to align perceived circumstances, rules, and desired outcomes. Ultimately, over time and through experience, these agents will begin to infer which rules fit best with the perceived circumstances to yield the most valued result.

Sometimes agents will discover that new rules are needed, or that circumstances need to be perceived differently in order to take reliably effective action. Knowledge is created as the product of reasoning about new ways to take more reliably effective action. Here we see that knowledge creation is the result of efforts by agents to more deeply understand the causal landscape that defines the organization and its environment, so that they may fulfill both their own and the organization's identity.

Identity enacts itself by guiding the behavior of agents in much the same way that DNA guides the actions of various animal species. Identity itself is composed of rules for action that guide the actions of agents who are seeking to fulfill their purpose. *Identity is the core set of generative rules that enable agents in the organization to self-organize and produce the organization's final reference point through this emergent process*. From this perspective, organizations are both self-organizing and self-referencing in redefining and serving their own identity through the knowledge creating processes. All living systems create knowledge to help them adapt and fulfill their purpose. Collins and Porras [5] propose that visionary companies exhibit a compelling drive for progress that enables them to transform and adapt without compromising their valued fundamental precepts.

Identity in Action

People normally think of a person's identity as being reflected by "who someone is over time". British systems theorist, Roger Harnden [6], for example, argues that identity is something that can be inferred through observing a system's behavior patterns. However, since our own subjective perceptions of such behavior patterns are the basis for making such inferences*, the identity we see may be colored by our own interests and our preconceptions of what types of behaviors are possible*. In the present discussion, we are more interested in a notion of identity that is operational within the context of the organization itself, rather than what others make of that identity.

Another, more useful, way of conceptualizing a system's identity is to view it as being a *"closed" network of relations instantiated by the components making up*

the system. This view of identity is most commonly associated with Maturana and Varela's explanation of autopoiesis. [7]

This is not to say that the system as a whole operates in a closed manner in relation to its environment. Rather, the relations that define identity are closed, or, do not refer to, the enclosing environment. Intuitively, the principle of systems defining their identity on the basis of cues originating internally makes sense, because the notion that identity depends on what's going on around the system seems nonsensical. The environment does, however, exert its effects on the system in the form of potential "perturbations" to the relations defining that system's identity. The system, in turn, selectively acts on the environment to manage these perturbations such that the system's identity is maintained -- if possible.

The general notion that identity serves as *the* activating force in shaping system-environment relations is not new. Maturana and Varela [ibid.] introduce the idea that natural systems seek to "conserve their identity" by establishing it as the foundation for all behavior. A critical aspect of the autopoietic notion of identity as a closed network of relations is that these relations are self-producing. In other words, the identified system is not merely maintained, but rather is continuously produced by a generative process reflecting these relations. It is by this notion of self-production that a system can both change and yet remain the same. To use an oft-mentioned example, the human body constantly processes flows of matter into and out of its cells such that every couple of months it could be said that a body was largely "new" in a physical sense. Yet, at the same time it remains the "same" body with regard to identity.

In organizations, we will call these identity relations *organizing principles* to emphasize their self-producing aspect in the social context. These organizing principles can range from ideas embodied in explicit policies to tacit knowledge about the best way to generate innovations in a company. McElroy [8] has termed this collection of rule-based systems and organizing principles as an organization's "knowledge operating system^{SM}**.**"

For our purposes here, it is important to recognize that these organizing principles include what it means to engage in knowledge management. On this point there is clearly a wide range of belief and practice. Some practitioners organize for knowledge sharing around the idea that managing knowledge primarily means to increase the speed and scope with which information is shared throughout an organization. For example, Costello [9] writes, "What users need is a knowledge infomediary; someone who knows what the company does, where knowledge resides within it, and in what form that knowledge may be valuable in contributing to the bottom line." On the other hand, Wenger [10] observes, "you don't manage knowledge. Communities of practice do. You

support them and involve them in the running of the organization. They own the knowledge, they steward it."

As we have said, understanding the underlying organizing principles that reflect an organization's identity is key to understanding what will be valued by the people in that particular organization, and will serve as the basis for much of the action taken within that organization. More specifically, we believe that these organizing principles are manifest as processes and structures that govern how knowledge is created, dispersed and validated. Furthermore, the same organizing principles will determine how these processes and structures can be managed -- that is, how Knowledge Management will be practiced.

We will certainly want to examine more closely this relationship between knowledge creation processes, knowledge management, and identity. But first, we must make more explicit what we mean by knowledge in the first place.

Knowledge

Argyris [11] 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 saying asserts "knowledge is power," whereas Webster's dictionary defines power as "the ability to do or act." Taken together with our previous assertions, these observations suggest that knowledge is related to the power of a person or group, to act in ways that are reliably effective at attaining valued results, which as we argued above, are ultimately tied to identity.

What exactly, then, do we mean by knowledge? To find the answer to that question, we must first go back to the concept of autopoiesis, which informed our notion of identity. As we said then, the interactions between the system and its environment are grounded by the closed network of relations defining the system's identity. Effects of the environment on the system are of the form of perturbations of those relations, and the response of the system to such perturbations is to attempt to mitigate them by acting, either inwardly (i.e., changing the system itself) or outwardly (i.e., changing the environment). In actuality, some of these actions will turn out to successfully mitigate the perturbation and some will not. An adaptive system will take note of these actual results and endeavor to perform those acts found to be successful in the past when similar conditions arise in the future. The adaptive change in the system, then, is “learning” those acts that can be potentially performed in the future to mitigate perturbations of the system’s identity. In other words, it is in terms of such inward and outward acts alone that an adaptive system will learn -- that is, create knowledge.

To this autopoietic view we will add the insights of the American philosopher Charles S. Peirce and his philosophical theory of 'pragmatism'. On this basis we

assert that the most essential definition of knowledge is that it is composed of and grounded solely in *potential acts* and in those signs that refer to them.

By act we mean an effort guided by a particular *rule* under particular *conditions* having a particular *result*. A *potential* act simply means that the system "knows" that if such conditions were to occur in the future, an effort guided by that rule would produce that anticipated result with some measure of reliability. If such anticipated reliability is high, then the potential act is considered a "belief." Conversely, if the potential act is considered unreliable, then it is a "doubt." From the perspective of the adaptive system attempting to maintain its identity, beliefs are to be pursued and doubts are to be avoided.

This principle was considered so essential by Peirce that he considered it the primary motivating force behind learning. He called it the "irritant of doubt" to convey the fundamental organic nature of this driving force. Peirce [12] 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." (p. 189)

Recall that acts can be both inward, as well as outward, by this definition. Some outward acts could be thought of as those that primarily affect a change in the system's environment—what we typically think of as "overt action." Other outward acts can have the primary affect of conducting an "experiment" on the environment, such that if the act is successful, it brings about the presence or absence of a particular condition in the environment. Such acts can be thought of as "perceptual" acts since they emphasize the role of orienting future acts to the state of the external environment. It is important to realize, however, that acts of any stripe may serve to orient future action. Much of the time, prior overt actions don't affect the environment as much as they set the stage for future action.

Inward acts are those that exert effort to effect change within the system itself. According to this view, "thoughts" or "cognitions" are simply inward acts that change the state of mind. According to Peirce, there are 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. These three types of inward acts are discussed in greater detail below.

We anticipate that such a view of knowledge will generate many questions and concerns, as more popular notions of knowledge obviously include other

concepts that do not appear to be accounted for in our compact definition. Perhaps the most obvious concern would be how our notion of knowledge accounts for what is commonly referred to as "mental models", or representations of the enclosing environment. There is little doubt that, at least in the human mind, there are representations of the external world within the system that rightly deserve to be called knowledge. One might ask, is this not supporting evidence for the insufficiency of our definition of knowledge? The resolution of this issue hinges on the understanding of another idea we generally take for granted - the concept of *representation.*

Maturana and Varela, [7] in describing what they referred to as the cognitive domain, point out that the autopoietic model of a system does not allow for information about the external world to "flow" into the system to inform the creation of representations of that world. Rather, the system must construct its representations on information it does have at hand -- namely, the acts it performs. In short, (because a more complete treatment of the concept of representation would fill volumes), we claim that representation means an internally constructed relation between that doing the representing (the "sign") and a complex of acts by which something thought to be "out there" can be recognized (the "object"). In this view, there is no necessary correspondence between the object of the representation and any "real" object that might actually exist, other than the system having found it valuable to believe that such a correspondence exists in managing its actions.

The notion that knowledge, in general, is established and confirmed only on the basis of experienced acts means that each potential act in knowledge is always in an intermediate state of confirmation, subject to further confirmation or refutation with each interval of new experience. In the mix of acts constituting knowledge there will be acts that have been shown to yield expected results, but there will also be acts with unproved and unknown potential to help us in attaining our desired results. A set of potential acts, or knowledge, that contains only those acts that have been proven, over time, to be always effective exists primarily as an ideal rather than a reality.

One might question whether this model of knowledge is generally applicable to organizational systems as well as individual biological systems. Admittedly, there are important differences between systems whose components are themselves autonomous—as are individuals making up an organization—and systems whose components are not autonomous—for example, the organs making up the human body. For example, in the human body there are certain organs—primarily the brain—where adaptive change is largely concentrated leading to highly coherent and interrelated adaptive activity, what we know as “mind” and “thought”. Adaptation in organizations, however, is naturally 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 the organization.

We can envision, however, an "ideal" organization with a well-defined and established identity and where all action was highly integrated through communication among all individuals. For example, in this ideal organization the inward act of thought of one individual would become part of the precursory condition for future acts, both inward and outward, throughout the organization. Similarly, the establishment of belief or doubt in the mind of an individual would consider the results of prior acts of all those in the organization.

While such an ideal is likely not to ever exist, the arguments we have made for our model of knowledge and identity are sufficiently abstract and general to be valid for this sort of system. Real organizations, from this perspective, are imperfect instantiations of this ideal, limited by their own capacity to communicate an ill-defined sense of organizational identity, amidst human processes filled with variety and unpredictability. Yet, we assert that our model is both *applicable* to such non-ideal organizations, as well as *valuable* in making real organizations more like the ideal. The problem before us then, is to make use of our concept of knowledge to inform the design of real knowledge-creating organizations that more effectively find, and establish a belief in, acts that are valuable to the organization in expressing its identity.

Approaches to Designing Knowledge-Creating Systems

The knowledge management literature is filled with models and methods for sharing both information and knowledge, but to date, relatively little has been said about designing knowledge-creating systems. [2] [3] [4] Let us review several of the more popular approaches to designing knowledge-creating systems.

From a historical perspective, people have been concerned for several millennia about finding better ways to design systems that ultimately yield knowledge that offers practical benefits. Ultimately, most discussions about the design of knowledge creating systems retreat back to assumptions about the very nature of knowledge itself.

Historians and philosophers often cite the seemingly divergent perspectives of Aristotle and Plato. Generally, these perspectives still shape the dialogue about the nature of knowledge in the modern practice of KM.

The fundamental debate centers on the primary role of sensation or sense experience. Some philosophers, primarily Aristotelians, argue that there is a direct correspondence between the human experience of sensing and that of rational thought. That is, this view holds that human sensation is explainable

in terms of a process of logic that flows from human thought. On the other hand, the Platonic perspective holds that human sense experiences are filtered through limited, imprecise human perceptual processes.

This debate still shapes many of the current disputes occurring within the knowledge management field, such as the relative importance of tacit versus explicit knowledge and defining the role of learning organizations in creating new knowledge [13]. Since *knowledge enables reliable effective action*, it is not of great importance to understand anything about whether knowledge is tacit or explicit. Rather it is more important to know if a form of knowledge can serve reliably as the rules for action to produce a desired result under a given perceived situation for large numbers of people.

Some may argue that tacit knowledge does not take the form of rules and is simply a more intuitive sense of what to do in a given situation. We reply that there is indeed a tacit dimension to knowledge, but it takes the form of agents not recognizing the rules they have been following to attain certain outcomes. There are also other forms of tacit knowledge that are based on feelings, intuitions, or sense perceptions. While these may have some usefulness in organizations, we suggest that they are extraordinarily difficult to transfer and should not serve as the foundation for any sort of knowledge system involving high risks or need for reliability.

There are numerous approaches to knowledge management that have been proposed by various authors. Some of these models only address knowledge creating processes implicitly, while others provide comprehensive explanations.

Models of Knowledge Creating Processes

Boisot [14] addresses the differences in types of knowledge commonly found in organizations. These differences are expressed as part of a matrix model that depicts possible combinations along two continua. These are: (1) codified versus uncodified, and (2) diffused versus undiffused. (Figure Two)

The essence of the Boisot model is that codified knowledge is much more easily transferred than uncodified knowledge. The critical knowledge-creating task for managers is seen as facilitating the transformation from uncodified to codified knowledge so that it can be diffused to become public knowledge. Boisot presents a high-level strategic view of organizations that offers a rationale for the argument that only codified knowledge can be well enough dispersed so it may become public knowledge. Unfortunately, he provides little advice as to the processes that would be necessary in order to make such a transformation.

Boisot's model is similar in many respects to the knowledge creation models developed in various iterations by Nonaka and associates. These include: Hedlund and Nonaka [15], and Nonaka and Takeuchi [1]. Like Boisot, Nonaka and Takeuchi posit the idea that knowledge can take various forms ranging from tacit to explicit. The theme of their approach is that various forms of knowledge are the catalysts necessary for creating new forms of knowledge. For example, if properly managed, tacit knowledge can be transformed to more useable, explicit form through various managed social processes.

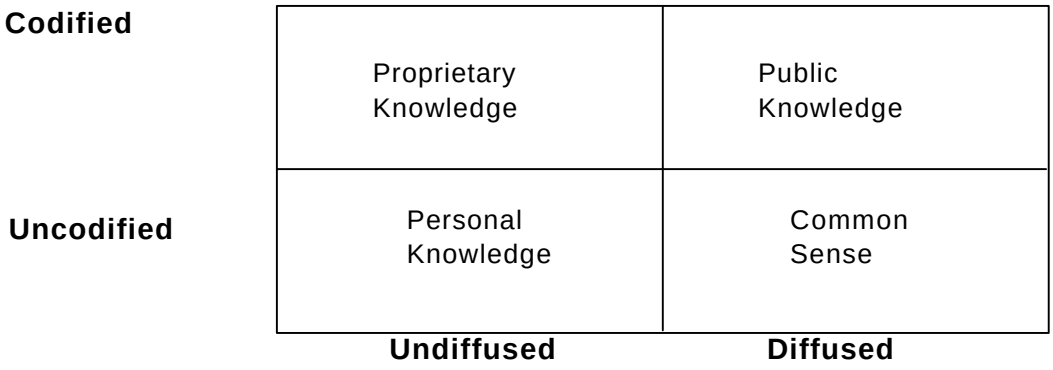

Figure Two -- Boisot's Knowledge Model

These processes include: (1) socialization, (2) internalization, (3) externalization, and (4) combination. According to Nonaka and Takeuchi, [1, P. 61] "Our dynamic model of knowledge creation is anchored to the critical assumption that human knowledge is created and expanded through social interaction between tacit knowledge and explicit knowledge. We call this interaction "knowledge conversion". It should be noted that this conversion is a "social process" *between* individuals and not confined *within* an individual."

These authors go on to say "the key to acquiring tacit knowledge is experience. Without some form of shared experience, it is extremely difficult for one person to project her or himself into another individual's thinking process." [ibid. p.63] Nonaka and Takeuchi explicitly point out that knowledge conversion equals knowledge creation. The central thesis of these authors is that knowledge is created by transforming what is fuzzy, and not clearly delineated, into a form that is more codified.

In the frame of our approach, based on inferential logic and interpretation of acts, the so-called conversion process is really a way of making knowledge claims and beginning to validate them. Does the Nonaka and Takeuchi

knowledge creation process address the important issues we have identified such as: (1) identity (2) act construction through logical inference, (3) semiotic interpretation and (4) autopoiesis? While they appear to address some of these issues indirectly through metaphor and case examples, they clearly do not provide a detailed method that can be easily followed. More importantly, we reject the notion that knowledge creation equals knowledge conversion outright.

Knowledge creating processes are a function of people's capacities to logically infer new relations among rules, circumstances, and desired ends, and to make semiotic interpretations that yield new and different meanings and models from existing facts. The Nonaka and Takeuchi model does not address knowledge at this level of granularity, rather it proposes an approach for managing organizational relations in such a way that knowledge

		To Tacit	*To* Explicit
From	Tacit	Socialization	Externalization
From	Explicit	Internalization	Combination

Figure Three -- Nonaka Takeuchi Model

conversion is a more probable outcome. However valuable such processes may be, the following question must be raised: Can knowledge managers effectively design knowledge-creating conditions without ever facing the question of how knowledge originates in the first place? We suggest that saying simply that tacit knowledge originates in human experience is insufficient for designing knowledge creating processes.

Hedlund and Nonaka [15] provide a more comprehensive model of the knowledge creation process that identifies four different levels of carriers or agents of knowledge in organizations. These are: (1) individual, (2) group, (3) organization, and (4) inter-organizational domain. These agents are viewed in this model as carriers of both explicit and tacit knowledge. Again, these authors appear to see the prime organizational task of knowledge managers as being the facilitation of knowledge conversion processes.

While this may be a worthwhile goal, it implicitly discounts the question of how new tacit knowledge is created. While it is popular to say that knowledge stems from learning and experience, the model does not say how this happens. It is worth noting that a large portion of the writings of the leading pragmatist philosophers, such as Peirce, James, and Dewey are focused upon this very question. The perspective expressed by Hedlund and Nonaka, that defines what actually constitutes the core of knowledge creating processes, is roughly the same as is found in Nonaka and Takeuchi. Therefore, the same limitations expressed earlier in this article apply here as well.

Von Krogh, Ichijo, and Nonaka [16] have written the latest iteration of this knowledge creating view based on the preeminence of knowledge conversion. There is a marked shift is this latest writing from a knowledge *management* perspective to a knowledge *enabling* perspective. This newer perspective proposes that knowledge-creation is a delicate process that must be handled with care. The message is clearly that knowledge conversion is is done better when knowledge is enabled to develop as part of a self-organizing process, rather than when it is managed.

By "enabling knowledge conversion" the authors appear to intend that the knowledge manager's key task is to endeavor to create those organizational conditions that effectively support knowledge-creating processes. These are laudable goals and seem consistent with the view that knowledge creation is a natural process that cannot be effectively controlled through the use of mechanistic control systems upon which most of traditional administrative theory is based. Five enabling behaviors are proposed as means to adeptly handle the fragility of knowledge-creating processes. These are: (1) Instill a vision, (2) Manage conversations (3) Mobilize activists (4) Create the right context, and (5) globalize local knowledge. These functions are placed in a matrix with five knowledge creation steps including: (a) sharing tacit knowledge (b) creating a concept (c) justifying a concept (d) building a prototype, and (e) cross-leveling knowledge.

Fundamentally, this approach represents a major refinement of the earlier approaches involving Nonaka. Nonetheless, the perspective that tacit knowledge is simply manifested from "experience" remains, as does the view that "socialization" is the key to making knowledge explicit. This view can be largely traced to the adoption of Polanyi's view that human beings create knowledge by involving themselves with objects, and that through a process he terms "indwelling," people acquire experience that translates into knowledge.

While there appears to be merit in this perspective, it fails to account for the fact that people are fundamentally driven by their identity to solve problems, seek desired outcomes, and fulfill their own obligations to their own and community identities through purposeful action. People and organizations are purposeful entities and indwelling or immersion in object-based experiences explains the context of knowledge creating experiences, but not the process. Von Krogh, Ichijo, and Nonaka have created a useful conceptual framework and method that accounts for a significant, but limited, part of the knowledge creation process.

Wikstrom and Normann ([17] propose that there are three types of knowledge processes that can be found in organizations. These are (1) generative processes (2) productive processes, and (3) representative processes. In generative processes the focus is on the new knowledge that is created as a product of problem-solving efforts. Productive processes take the form of accumulated knowledge that people in organizations employ to create value in the form of products and services for clients. Representative processes are a type of knowledge in which the organization makes its insights and understanding available to customers for helping in purchasing or using products. Much like Nonaka's earlier knowledge management models this approach offers a typology of various kinds of knowledge. Its greatest contribution is that it introduces the idea of generative knowledge processes in organizations. This is an important concept with regard to linking organizational identity to knowledge creating processes.

Choo [18] proposes that knowledge creation is a major element in what he terms the "knowing cycle". In the knowing cycle the knowledge creation process is linked with decision-making and sense-making as part of a reiterative learning cycle. According to Choo, organizations create and exploit knowledge for two main purposes, to: (1) develop new capabilities and (2) create new innovations. The notion that knowledge plays a critical role in innovation has been undervalued and is just beginning to gain attention in the knowledge management community. In this model there are three basic elements to knowledge creating processes: (1) generating and sharing tacit knowledge, (2) testing and prototyping explicit knowledge, and (3) linking and tapping external knowledge. Choo's model appears to follow the same set of assumptions and limitations as Nonaka and Takeuchi, and subsequent versions of Nonaka's work.

Leonard [19] has designed a similar type of high-level managerial view of knowledge creation that is based on viewing the key task of management as being the enhancement of the core capabilities of an organization. She views problem-solving and experimenting as the two main catalytic functions that trigger knowledge creating processes. Of all the models reviewed, this one says the least about the nature of knowledge, epistemology, or knowledge-

creating processes. Rather, the emphasis of Leonard's work appears to be on explicating lessons learned about successful knowledge creating companies from case studies. It would seem however, that any effort to cull lessons learned from practice should start with a minimal *a priori* definition of knowledge and the knowledge creating process.

Demerest [20] provides a more holistic, process-oriented view of knowledge creation. Knowledge construction is depicted as having two basic elements: (1) scientific paradigms and (2) social paradigms. In this approach knowledge is seen as becoming embodied in the organization both through routines and programs, as well as social networks. The Demarest model is iterative and reflects an action/learning orientation in the sense that knowledge is seen as evolving in a cyclical manner from construction to dissemination to use, then to embodiment and finally back to construction again.

The weakness of this model is that it fails to clearly define knowledge or address the important relationship between knowledge and routines. In a number of perspectives routines are regarded as an important form of knowledge. Overall, Demarest advances the discussion of knowledge creating processes by placing knowledge creation within the framework of organizational learning. Relatively few writers have endeavored to make the connection between organizational learning and knowledge creation as explicitly as appears to be warranted.

In summary, the clear emphasis in most of the knowledge creation models discussed in this section is on managing organizational processes for knowledge conversion. Though Von Krogh, et al, and to a lesser degree, Demarest, have stressed the point that knowledge creation is not very amenable to production via management and control, there is still a heavy managerial orientation in all of the models reviewed. Virtually all of the models ignore dynamics, complexity, and self-organizing processes to emphasize the descriptive non-process elements of knowledge creation.

An even more glaring omission in these models is the absence of a clear systems approach to knowledge creation. John Holland's [21] work with complex adaptive systems (*cas*) provides a fertile framework for capturing the essence of knowledge creating systems. Other systems approaches, such as system dynamics, might seem equally well suited to address this need. We will propose a model that begins to address some of these issues including the role of self-organization in knowledge creation.

A Model for Knowledge Creating Systems

- The Act

As we have made much use of the concept of an *act* so far, we cannot proceed without more detail about the act concept itself. In doing so, we will again draw heavily on the work of Charles S. Peirce. Peirce is widely known as America's greatest philosopher and mentor to such notable figures as William James and John Dewey.

An act is a triadic (three-way) relation between a: (1) Case (2) Rule and (3) Result.

- A *Case* is the perceived situation that enables the act to be performed. For example, in order to swat a fly -- it must first be within reach.

- The Rule is 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 "Swat the Fly" is an act that can be specifically accomplished in an infinite number of ways at greater levels of detail (e.g., different swatters, different starting positions of the hands, etc.)

- The *Result* expresses the anticipated consequences of having acted. [22]

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 hypothetical conditions specify the Rules of other acts that can be recognized or performed according to their respective potential acts also found in knowledge. Accordingly, there is a hierarchical layering of potential acts in knowledge, beginning with the most elementary and ending with the most abstract. More abstract potential acts tend to refer, in their Cases and Results, to the Rules of more elementary acts. Figure Four illustrates this layering.

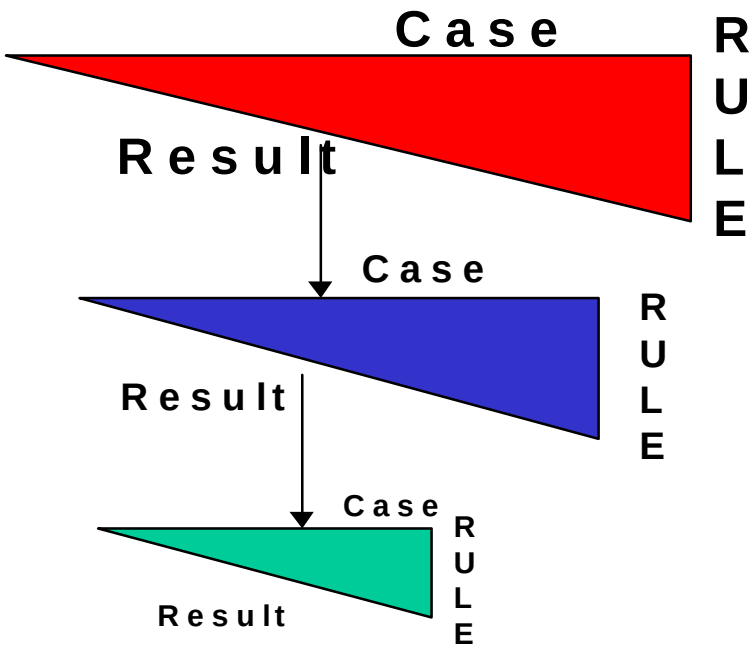

Figure Four -- Cascading Hierarchy of Acts

Pragmatic Logic

According to Peirce, three types of reasoning can be applied to acts. These are: (1) deduction (2) induction, and (3) abduction. These three forms of inference work together to both apply existing knowledge as well as to create new knowledge.

Deduction is reasoning from the Case and the Rule to anticipate the Result. In Deduction, the Case is an existing fact having already been experienced. Given this fact and the law named by the Rule of the act under consideration, Deduction infers a future or consequential fact, the Result of the act. For example, one can Deduce from the fact “(1+1)” and the Law of Addition a consequential fact “2”. Because the antecedents of Deduction are a fact and a law, the inferred results, then, necessarily follow. In other words, if both the Case and Result are true, the consequent Result obtained by Deduction must also necessarily be true. Of the three forms of inference, Deduction is the only one having this character. It is also probably the best known form of inference and is usually what comes to mind when the term "logical" is invoked.

Induction is inference from a Case and Result, both appearing as facts in experience, to the Rule of a potential act in knowledge. Notice that Induction works entirely in the past, seeking to explain actual experience in terms of

existing knowledge. Also unlike Deduction, Induction is only "possible" rather than necessary. Even if the Case and Result are true, there is no guarantee that an inferred Rule is the correct one. For example, if the Case is a *buzzing fly* and the Result is a *dead fly*, the Rule might be *Swat the Fly*, but it also might be *Old Age*.

Abduction is a logical process that creates or modifies knowledge on the basis of "logical" observations arising from Induction applied to experience. The observations are logical, in that they are observations of the process of Induction per se, rather than on the content to which Induction was applied. Such observations include estimates of the relative frequency of both the application of potential acts in existing knowledge as well as their relative rates of success.

Induction may also identify a number of surprising facts that cannot be explained using knowledge presently available. In this case, the logical observations note the circumstances under which this surprise occurred. From these observations resulting from Induction (i.e., a Result), and logical laws relevant to how knowledge *ought to be* (a Rule), Abduction infers what specific problem must have existed in knowledge to have produced those logical observations (i.e., the Case). This consequence of Abduction is then used to modify knowledge, such as the addition of new potential acts or modification or elimination of existing potential acts. Like Induction, Abduction is not a form of necessary reasoning and may not always lead to the correct consequent.

When, and if, a system embodies knowledge adequate for its present environment, knowledge creation and modification through Abduction are no longer necessary for the present. Under such circumstances, Induction and Deduction iteratively operate in a loop we call a Performance Loop. Induction, operating on past experience, infers (but not with certainty) what acts and rules were operant during that period of experience. The consequential Rule arising from Induction then becomes the Case for a Deduction of a contemplated act. Deduction infers the possible anticipated Results obtaining from potential acts in knowledge given the Induced Case. With satisfactory knowledge rather than with information that we mistakenly thought was knowledge these Results will actually be attained, thus meeting the ultimate objective of reliable action (i.e., that produces the anticipated result).

On the other hand, when the system's knowledge is inadequate, either from lack of learning or because the environment has changed, the anticipated Results are not obtained. In this case, Induction and Abduction will be called on to iteratively operate in a loop we call an Inquiry Loop.

In actuality, a system may shift back and forth between Inquiry and Performance modes with more or less rapidity depending on the situation. In a nearly pure Inquiry mode, a person may sit quietly and contemplate past experience in order

to better understand it. On the other hand, under high stress and rapidly evolving conditions, a person may just "go with what they have" invoking habitual rules without taking the time to consider how they might do things better. This would be essentially a pure Performance mode. In most circumstances, however, there would be a constant shifting between the two.

A Case Example: Production Planning

A production control manager in a manufacturing company is charged with setting a production target for the coming month. Previously she checked production for the prior month and found that it was slightly above the target. Later, she checks the current finished goods inventory and finds that it is below normal. This sequence of experienced facts present in the thought of the manager includes the Case (higher production) and Result (low inventory) from which a possible Rule may be Induced.

Presently, this manager has several potential thought-acts in knowledge that could be induced, for example:

CASE	RESULT	RULE
High Production	Low Inventory	Theft
High Production	Low Inventory	Increasing Demand

This time, she Induces that her customer base has bought more product than the average historical demand, resulting in the lowered inventory. The situation (Case) has now been abstracted to a more general rule present in her mind (Increasing Demand). From this Case and the potential act in Knowledge:

CASE	RESULT	RULE
Increasing Demand	Normal Inventory	Increase Production

she Deduces that if she acts to set a production target for the next month at a level equal to the average monthly demand, plus the current inventory deficit plus an extra margin to account for increased demand, (Rule) then she expects to have her inventory back to normal levels by the end of the month. (Result) She sets that target and waits a month to see if her act/target-order produced the Result.

A month later, she checks and sees that inventory is now above normal level by an amount essentially equal to the extra margin she included in last month's target. In other words, the act did not produce the anticipated Result. She Induces from the observed fact that production was on target (Case) and that inventory was above normal (Result) but that another potential act currently in knowledge, demand:

CASE	RESULT	RULE
On-target Production	High Inventory	Decreasing Demand

is now going down.

This, in turn leads to another Deduction based on the potential act in her knowledge:

CASE	RESULT	RULE
Decreasing Demand	Normal Inventory	Decrease Production

This time, she sets a reduced monthly target, anticipating that the inventory will finally return to normal.

At the end of the following month, she is surprised and dismayed to find that once again she has failed to return inventory levels back to normal. Notice that the manager has been operating in Performance mode, iterating between Inductive and Deductive inferences.

In response to these surprises, the manager shifts to Inquiry mode and gathers his production and inventory records for the past several years. She again performs Induction on these facts and finds that inventory levels and predicted demand have been unreliable, but in a pattern that suggests a new idea -- perhaps the demand naturally varies from month to month in a predictable way because customers buy more or less product depending on whether the month contains a major holiday.

As a result, she creates (Abduction) a new act/rule in her knowledge that includes the holiday factor. Taking the present inventory level, as well as next month's calendar into account as the Case for her act of setting a target, she returns to Production Mode and deduces that she will finally get inventory under control. As it turns out, she was successful this time and for most months afterwards. These future Inductions again provide relevant facts for a future Abduction that eliminates from knowledge those target-setting acts that do not account for monthly variations in demand, since they have proven to be significantly less reliable than those that do account for variations in demand.

Knowledge Management

The above example illustrates the essence of scientific reasoning because it creates and maintains knowledge according to whether it leads to reliable actions, not on the basis of arbitrary authority or agreeableness. Yet, there are many different knowledge-creation processes possible that meet these general conditions and would be considered scientific. As we argued earlier, these variations will be largely determined by organizing principles reflecting the identity of the organization. Some examples of ways in which knowledge-creating processes might vary include:

- the rate at which Abductive hypotheses are introduced into knowledge,
- the rate at which the presumed reliability of existing acts are adjusted in light of recent experience,
- the conservative-vs.-progressive bias of Abductive hypotheses
- the number of competing Inductive and Abductive alternatives that are maintained, and so on.

Furthermore, we also previously argued that the meta-process -- what we are claiming to be the correct notion of Knowledge Management -- that manages the knowledge-creation process, is also determined by the organizing principles as well. Any effort at knowledge management within a particular organization must be cognizant of how these organizing principles are at work at both these levels -- the object of knowledge management, the knowledge-creating processes themselves, as well as the meta-level processes.

As a start, one could imagine the influence of organizing principles and organizational identity on knowledge management per se, as setting maximum rates of change and allowable regions for the parameters previously identified for the knowledge-creating process, for example:

- how fast and how far the rate of Abductive hypothesis-making can be changed to improve overall knowledge creation performance will vary with an organization's identity profile,
- what levels of conservatism and progressiveness will be seen to be outside of the bounds of the organizational identity will also vary with an organization's identity profile, and so on.

In short, the state and adaptability of knowledge-creation within an organization will eventually raise questions about "who we are". The prudent knowledge manager will seek to understand how these questions will arise and how they will likely be answered.

Conclusions

Despite the pervasive popular view that knowledge conversion is the basis of knowledge creation, we propose that knowledge creation is a process of inferential reasoning based upon the use of acts that perform reliably well and to fulfill identity. Identity is the starting point for all knowledge creating processes because the self-referential and recurring rules that form identity give rise to the emergent behavior of agents. Agents may act alone or as part of a self-organizing collective, such as a community of practice, that endeavors to validate knowledge claims for the viability of certain acts proposed via Abduction by these agents. Agents create new knowledge by reasoning in various ways, using deduction, induction, and abduction, to

create new configurations of case-rule-result triads. Knowledge is the store of potential acts that may be used to produce a desired end under a perceived set of circumstances.

Many knowledge management initiatives are based on the premise that knowledge creation should be done because it is intrinsically worthwhile or because it will lead to a positive outcome, such as greater levels of innovation. While knowledge creating processes may be intrinsically worthwhile and lead to innovation, there is only one overriding reason that knowledge should be created -- to fulfill the organization's identity. Currently popular notions within the knowledge management community, such as sharing best practices and knowledge conversion represent the harvesting of the low hanging fruit of knowledge management. Clearly there is some leverage in these and similar practices. However, the greatest leverage lies in innovating how people in organizations think about solving problems and improving the reliability of their problem-solving performance. Organizations, like scientists, are discovering that it is difficult, if not impossible, to create new knowledge when people continue to reason in the same ways -- without awareness of the limits of their ways they reasoning. The essence of the knowledge creating process lies in using reasoning to create new meanings that have never existed before.

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