Action and Possibility: Reconciling Dual Perspectives of Knowledge in Organizations

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Abstract

At times knowledge can be seen as the source of organizational innovation and change—at other times, however, it can be the very constraint on that change. This conflicted role offers insights into why the phenomenon of organizational knowledge has been interpreted by researchers in multiple and possibly conflicting ways. Some theories depict knowledge as an empirical phenomenon, residing in action and becoming "organizational" in the acquisition, diffusion, and replication of those actions throughout the organization. Others consider it a latent phenomenon, residing in the possibility for constructing novel organizational actions. This paper argues that while each of these qualities—empirical and latent—are intrinsic to knowledge in organizations, our understanding of organizational phenomena is essentially incomplete until the relationship between them is considered. Building on structuration theory, we propose a complementary perspective that views organizational knowledge as the product of an ongoing and recursive interaction between empirical and latent knowledge, between knowledge as action and knowledge as possibility. We ground this complementary model of knowledge in evidence from the field study of two firms whose innovation practices provide unique insights into how knowledge simultaneously enables and constrains behavior in organizations. We then discuss how a complementary perspective avoids the reification of knowledge by depicting it instead as an ongoing and social process and offers an alternative distinction between individual and collective knowledge.

(*Knowledge Management*; *Organizational Learning*; *Innovation*; *Structuration Theory*)

At the turn of the last century, physicists attempting to understand the properties of light had divided into two camps, each holding conflicting theories, each supported by empirical findings. On one side stood Einstein and others, whose experimental results demonstrated that light had a finite velocity which could only be explained by theoretical models viewing light as matter. On the other side, experiments demonstrated that light had electromagnetic properties that could only be explained by theories viewing light as energy. The debate over such conflicting empirical findings and models continued until 1927, when Niels Bohr proposed his theory of complementarity (Folse 1985). Bohr suggested that a single model could not adequately explain the observations made in different experiments; in some experiments light will appear as energy, in others it will appear as matter. These dual characteristics coexist and it was the theoretical model driving the experiment, not the phenomenon, that determined which was demonstrated.

There are two parallels between the early study of light and the current study of knowledge in organizations. First, recent reviews have suggested multiple origins for the study of knowledge in organizations (cf., Nonaka and Takeuchi 1995, Porac et al. 1996, Crossan et al. 1999), and we propose that this diverse intellectual parentage reflects two primary and distinct theoretical approaches. On one side are approaches that focus on the empirical qualities of knowledge. From this perspective, knowledge exists in the organization's actions—the physical and social artifacts of the organizations that include, for example, technologies, routines, standard operating procedures, blueprints, products, processes, databases, and even physical layouts of the organization (Nelson and Winter 1982, Levitt and March 1988, Huber 1991, Cohen and Bacdayan 1994). The phenomena of interest in this approach involve how organizations and their participants acquire, store, retrieve, process, distribute, learn, unlearn, encode, and in other ways replicate existing knowledge. On the other side are approaches that focus on the emergent, latent qualities of knowledge. From this perspective, knowledge exists as the possibility for generating novel organizational artifacts. Here knowledge represents the beliefs and values of organizational participants and is context specific, dynamic,

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and continually subject to negotiation, transformation, redefinition, and recombination (Kogut and Zander 1992, Weick 1995, Leonard-Barton 1995, Nonaka and Takeuchi 1995). Here the phenomena of interest include how organizations and their participants generate, create, innovate, deviate, and in other ways produce new knowledge where it had not existed before.[1]

The second parallel between the early study of light and the emerging study of knowledge in organizations lies in the effects these competing perspectives have on interpretations of organizational phenomena. Difficulties emerge because organizational scholars can and often do interpret organizational phenomena as evidence either for the accumulation and replication of existing knowledge or for the generation of new knowledge. Which aspect of a given phenomenon is noticed depends on which research perspective is taken. For example, improvements in an organization's new manufacturing process may represent the learning curve—linking productivity to experience—and serve as evidence for the accumulation and routinization of useful physical and social artifacts (Wright 1936, Epple et al. 1991). The same phenomenon, from an alternative perspective, suggests that early stages of production provide opportunities for innovation on the manufacturing floor—opportunities that may disappear over time as emerging and pliable work practices become encoded in the artifacts of the organization (Tyre and Orlikowski 1994, Bechky 1999). The former interpretation suggests ways in which new knowledge enables the evolution and replication of an organization's physical and social artifacts; the latter interpretation considers the ways in which those same artifacts constrain the possibilities of new knowledge. Like the early models of light, these different theoretical interpretations have the potential to shape our understandings of organizational knowledge and knowing in distinctly different ways.

The intent of this paper is to recognize these differing perspectives in the existing literature, explore their influences on the study of knowledge in organizations, and develop formal links between them. To understand the means by which knowledge simultaneously enables and constrains behavior, we call attention to the complementarity between perspectives of knowledge as artifact and knowledge as possibility. Such a complementarity can be found in the structurationist perspective of Anthony Giddens (1979, 1987).[2] Giddens argued that the opposition of structure and action could be overcome by recognizing that the two are inseparable aspects of social life, forming a duality that is better described as an ongoing and recursive process. Social structure influences individual action but is, at the same time, made up of those actions: "every process of action is the production of something new, a fresh act, but at the same time all action exists in continuity with the past, which supplies the means of its initiation" (Giddens 1979, pp. 69–70). Orlikowski (1992) and Barley (1990), for example, have used this perspective to describe the relationship between technology and structure in new product development and in technology adoption. We similarly employ the structurationist arguments to suggest that organizational knowledge can best be understood as a process of interaction, or a duality, between the two qualities of knowledge. Such a view suggests knowledge may be better understood as a process whose evolution occurs in the cycles of interaction between knowledge of action and knowledge of possibility (see also Boland and Tenkasi 1995, Sevon 1996). In essence, the knowledge of possibilities constitutes action and the knowledge of action constitutes possibility.

A complementary perspective offers an explanation for the ways in which organizational knowledge at times enables action by facilitating organizational learning and innovation and, at other times, constrains action by hindering these processes. The physical and social artifacts of the organization are enabling when they allow acquiring, copying, and replicating existing knowledge. Conversely, these artifacts are constraining when they also represent the surrounds which cue, or prime, particular schema and the surrounds from which that schema was constructed. On the other hand, latent knowledge is enabling in allowing individuals (and ultimately organizations) to deviate from existing patterns of action within a particular situation through the imagination of new possibilities. It is constraining in that it interprets the situation through an existing schema representing similar past situations and constructs new possibilities for action from the limited set of experiences with past actions in that prior schema. We first juxtapose the existing perspectives of knowledge in the literature, and then develop a set of ideal types (Hekman 1983, Mouzelis 1968) forming a complementary perspective of knowledge in organizations. Such a perspective addresses the dynamic relationship between old and new knowledge and the contextual conditions of its replication and evolution. We then explore and ground this complementary model of knowledge in field research on one set of firms that have been shown to routinely generate novel possibilities by recombining their accumulated knowledge. The replication and evolution of knowledge in these firms illustrates the interaction between knowledge as action and knowledge as possibility.

Dual Perspectives on Knowledge in Organizations

Research on knowledge, knowing, and knowledge management has recently and rapidly entered the field of organizational studies, yet the assumptions and research approaches are, in some ways, already old and familiar.

Considerable work has previously focused on how organizations think, beginning with March and Simon's (1958) mapping of the cognition metaphor onto organizations. Many literatures have contributed to the study of knowledge, and this earlier work often reflects, and possibly contributes to, the dual perspectives of knowledge in organizations. Rather than attempt a broad review we focus instead on two dominant research models, the innovation and organizational learning literatures. We use these literatures as archetypes for the purpose of juxtaposing competing assumptions about organizational knowledge, while suggesting that each literature relies on an implicit acceptance of the activities of the other.

The innovation literature considers the processes through which organizations create new and useful actions such as products, work practices, and services. Damanpour (1991), for example, describes the innovation literature as encompassing the generation, development, and implementation of new ideas or behaviors. Kanter (1988, p. 170) defines innovation as "the creation and exploitation of new ideas," and Van de Ven (1986, p. 590) as "the development and implementation of new ideas." From an innovation perspective, knowledge provides the organization with the potential for novel action, and the process of constructing novel actions often entails finding new uses or new combinations of previously disparate ideas (Schumpeter 1934, Weick 1979b, Kogut and Zander 1992, Hargadon and Sutton 1997). In this way, the process of innovation represents the conversion of what an organization knows how to do into actions it has never done before. And the study of innovation reflects various attempts to understand the individual, organizational, and environmental factors that mediate between an organization's existing knowledge and its creation of novel actions (Damanpour 1991, Wolfe 1994).

On the other hand, the organizational learning literature considers the processes that convert an organization's experience (its actions) into possibilities for future action (what it knows how to do). In this way, organizational knowledge derives from the experiences of organizational members—including their observations of others' actions—and is stored in individual memories and in the ongoing routines, products, processes, and other replicable actions of the organization (Huber 1991, Walsh and Ungson 1991). From this perspective, knowledge begins in experience. As Levinthal and March (1993, p. 97) argue, "learning presumes interpretation of experience." And the acquisition of knowledge through learning occurs, as Huber (1991, p. 89) argues, when an organization "changes the range of its potential behavior." Cohen and Bacdayan (1994), for example, have demonstrated this learning process in action through their laboratory study of interactions within teams, showing how the routinization of this interaction improves performance under similar conditions but, at the same time, constrains performance through the invocation of inappropriate routines when the rules of the game have changed. The study of organizational learning reflects attempts to understand the individual, organizational, and environmental factors that come between that experience and the knowledge of possibilities acquired from it.

The innovation and learning literatures, as briefly described above, resemble the early and opposing approaches adopted for understanding the phenomenon of light, as well as the epistemological debate between "structure" and "action" (Giddens 1984). In the domain of organizational knowledge, adopting a single perspective of innovation or organizational learning becomes costly in terms of what may go unnoticed. An innovation perspective, while focusing on how organizations exploit their existing knowledge in novel ways, pays little attention to how those organizations built their stores of knowledge in the first place (Fiol 1996). Similarly, a learning perspective, by focusing on how organizations build stores of knowledge, pays little attention to how that knowledge might (and sometimes must) be used in unintended and innovative ways. We summarize these perspectives in Table 1. It is our contention that a fuller understanding of the role of knowledge in organizations may be found by complementing these opposing assumptions.

A complementary perspective recognizes the dynamic reciprocal relationship that exists between learning and innovation. Previous learning through the adoption and replication of existing actions shapes the possibility for future novel actions. Similarly, the generation of novel actions provides opportunities for encoding (or recoding) those actions in ongoing routines. Yet the relationship between past learnings and future actions is complex. Cohen and Levinthal, for example, have described how an organization's past learning is critical for their future innovation: "the organization needs prior related knowledge to assimilate and use new knowledge" (1990, p. 128). On the other hand, Leonard-Barton (1992) and Dougherty (1995) have shown that prior related knowledge can impede future innovation; core capabilities, as knowledge that shapes an organization's products, processes, and structures, can also act as core rigidities to prevent the organization from changing further. As such, more explicit understanding is required of the relationship between latent and empirical qualities of knowledge.

A Complementary Approach to the Study of Knowledge

When an automobile manufacturer develops a new carburetor or an insurance firm devises a new procedure for

Table 1 Two Perspectives on Knowledge in Organizations

	Innovation perspective	Learning perspective
Dominant research questions	Which factors explain the innovative capabilities of individuals and organizations? How does innovation unfold over time?	Which factors explain the modification of the available behavioral alternatives? How is knowledge acquired, distributed, interpreted, and stored?
Assumptions	Innovation is the creation and exploitation of new ideas from the preexisting characteristics and knowledge of the innovator.	Learning is the acquisition and retention of existing knowledge through experience with the external environment.
Implicit quality of knowledge	Knowledge is a latent construct, representing the potential for generating novel actions.	Knowledge is an empirical construct, representing the potential for acquiring and replicating existing actions.
Central process considered	The conversion of latent knowledge, comprising locally held but socially derived scripts, goals, identities of individuals, into empirical knowledge, the resulting physical and social artifacts of action	The conversion of empirical knowledge, derived from experiences with the physical and social artifacts of the environment, into latent knowledge, the scripts, goals, identities that make future, novel action possible

processing claims, we recognize the generation of knowledge in these organizations where it had not existed before (Weick 1979b, Nonaka and Takeuchi 1995). At the same time, however, an organization's capacity for generating new knowledge depends upon the prior knowledge it already possesses (Cohen and Levinthal 1990). For example, in designing a new carburetor, engineers in the automotive firm rely on their preexisting understandings of engineering and manufacturing to recognize the potential for such an innovation, to adopt the necessary components to make it work, and to develop the necessary routines for manufacturing it. Such previous knowledge includes the application of relevant past knowledge, such as the characteristics of previously designed fuel-injector nozzles. It also involves the recognition and adaptation of previously irrelevant knowledge—perhaps a new nozzle design used in NASA booster rockets. And it involves the recombination of a variety of past ideas, such as how to integrate a new nozzle design within an existing component. This previous knowledge represents the latent knowledge—the raw materials that an organization uses to construct new knowledge.

We propose that, as an ideal type, this latent knowledge is an individual-level phenomenon representing the schemata held by individual members of the organization. Schemata are relatively persistent knowledge structures for representing elements and the relationships between them, and are situated within a particular context (Schank and Abelson 1977, DiMaggio 1997). They serve as simplified representations of knowledge and, as such, as a means for simplifying cognition in conditions of incomplete information (Berger and Luckmann 1967, DiMaggio 1997). Schemata both constitute and structure knowledge by identifying those elements of a situation that are salient and by describing the causal relations between them: the knowledge to identify a carburetor (what it is and what it is not), to make sense of it (what it does), and to know the relation between its components (how it works). However, schemata provide more than simply objective representations of a particular situation, they also provide the interdependent scripts, goals, and identities that locate individuals within these situations. *Scripts* serve as templates for action within certain schemas and provide the set of tasks or behaviors appropriate to highly particularized situations (Barley 1986, DiMaggio 1997). *Goals* guide action by directing attention to particular aspects of that situation (Weick 1995) and by placing values on the outcomes associated with the alternative scripts available. While individuals' personal goals exist and may indeed contradict organizational goals, our focus here is limited to the individual-level instances of organizational goals. Indeed, early organizational theorists such as Barnard (1938) and Simon (1947) have described organizations primarily concerned with influencing potentially divergent individual goals. In this way, goals represent the individually held and organizationally shared knowledge of purpose (Cyert and March 1963, Thompson 1967). Finally, *identities* relate individuals to preestablished roles in particular situations and, by doing so, determine the appropriate goals and scripts available to them (Goffman 1959,

Berger and Luckmann 1967, Bandura 1978, Dutton and Dukerich 1991).

Taken together, the schemata—comprising scripts, goals, and identities—of members of an organization make up the latent knowledge available within that organization. For latent knowledge to act as the raw material for new artifacts, all three forms of knowledge must evolve: a change in scripts that recognizes the applicability of previously irrelevant actions (replicating the design of a NASA rocket valve); a corresponding change in goals (new performance possibilities are noticed); and identities (the automotive engineer momentarily becomes a rocket scientist). So while we analytically distinguish these three elements of latent knowledge, we recognize that they are empirically inseparable. Schemas identify goals and identities within situations, goals direct attention to particular situations and value particular identities, and identities determine the interpretation and valuation of opportunities and obligations. While individually held, schemata are powerfully influenced by the surrounding social *milieu*, and as a result members of an organization often come to hold similar schemata (Beach 1997). From the perspective of the organization, this latent knowledge held by its members represents the source of novel actions.

DEFINITION 1. Latent knowledge represents the individually held schemata of organizational members and this knowledge constitutes the precondition for novel action. In its ideal-typical form, this condition determines novel behavior by providing the raw materials for such action.

While novel actions signal the generation of new knowledge in organizations, repeated actions signal the acquisition and use of existing knowledge (Weick 1979b, Huber 1991). Returning again to the automobile manufacturer and insurance firm, the successful introduction into mass manufacture of a new carburetor design or the implementation of standard operating procedures surrounding a new claims process signals the incorporation of empirical knowledge into the repertoire of routines now available within the organization. This knowledge, now resident in existing action, guides future action; it represents the empirical knowledge that an organization now depends on to replicate itself over time, across situations, and between individuals (Kogut and Zander 1992). So while latent knowledge exists as the potential for novel action, empirical knowledge exists in action. In its ideal-typical form, empirical knowledge resides with the physical and social artifacts produced: the products of an organization, the tools used to produce them, and the routines directing the use of those tools. For example, embedded in the new carburetor are ideas about nozzle designs and other engineering principles, manufacturing requirements, and other physical and organizational necessities. Similar knowledge is embedded in the molds and machine tools used to produce such an artifact, and in the routines of the machinists, assemblers, managers, buyers, and suppliers involved in the process. As Tsoukas (1996, p. 16) describes, this knowledge resides "in the practices in which [the individual] participates . . . his understanding is implicit in the activity in which he engages." Through the experiencing of such actions by participation or by observation, individuals construct, reconstruct, and/or modify the scripts, goals, and identities that make up their relevant schema encompassing such work. For example, by observing a competitor's claims process and reflecting on its features, members of an insurance firm may refine their own understandings of what is possible or desirable within their organization. In essence, the empirical knowledge that surrounds individuals within organizations provides them with the raw material for constructing their related schemata.

DEFINITION 2. Empirical knowledge encompasses the physical and social artifacts that surround individuals in organizations. In its ideal-typical form, this knowledge is the only material from which individually held schemata emerge.

Note that it is impossible to link latent or empirical knowledge to action singly without recognizing the role played by the other. Latent knowledge comprises the schemata constructed and shaped from each individual's past experiences. Similarly, empirical knowledge can only be experienced through the lens of an individual's existing schema for that situation (Piaget 1980). Yet while each profoundly shapes the other, latent and empirical knowledge cannot be subsumed one into the other. The relationship between latent knowledge as the tools for constructing (even construing) our possibilities, and empirical knowledge as the surroundings from which we build these tools, thus reflects the duality of structuration of Giddens (1979, 1984). This relationship also reflects the process of cognition defined by Maturana and Varela (1987), in which systems simultaneously respond to and enact their environment through the internal structures they have constructed to perceive it. To treat latent and empirical knowledge as similar is to ignore the implications of the different loci of knowing; to treat them separately is to ignore the influence each has on the other.

By exploring this cycle of interaction we might come to understand how knowledge simultaneously constrains and constitutes novel action in organizations. Latent and empirical knowledge are connected recursively by two

processes: the conversion of latent knowledge to empirical and the conversion of empirical knowledge to latent. The former has to do with using knowledge to create a physical or social artifact and is consistent with how innovation theories depict processes that generate novel actions from a given set of resources. In this way, what our fictional automotive engineers knew about carburetors, about their goals, and about themselves (their identities) made possible the ultimate solution they arrived at.[3] From this perspective, latent knowledge constitutes the actors involved and guides their actions; these actions in turn generate and represent empirical knowledge.

DEFINITION 3. The conversion of latent knowledge to empirical knowledge refers to the application of knowledge latent in individuals to generate a physical or social artifact.

In an ideal-typical form, the resulting empirical knowledge does not modify the latent knowledge that produced it; any solution drawn from an existing schema is coherent with the initial conditions that produced it. In the strictly universalist and objective sense, this definition does not allow for innovation to occur because all new actions emerge from the knowledge of past actions. And yet, perfect imitation is rare if it is possible at all, as adopters seldom passively adopt an innovation. More often they adapt it to fit their existing practices and, in the process, create new actions (Weick 1979a, Sevon 1996, Hargadon and Sutton 1997). Focusing only on this process, the perspective of the innovation literature neglects the necessary and complementary phenomenon: the reconstruction of latent knowledge through experience, or the conversion of empirical to latent knowledge.

In reality, experiencing the surrounding physical and social artifacts reconstructs the latent knowledge available to an individual. In other words, extant solutions from the environment are never simply applied to novel problems. They are instead interpreted in light of the contextual conditions the actor perceives, before being used to construct new action. Our hypothetical carburetor engineers could not simply apply a NASA rocket booster valve when designing a carburetor. The necessary transformation of that empirical knowledge into latent knowledge for use began with the initial perceptions of the booster valve as a potential solution, triggering a reflexive process that was completed when the engineers' schema representing the situation had changed.

DEFINITION 4. The conversion of empirical knowledge to latent knowledge refers to the reflexive experience of individuals within the organization. It proceeds from the experience with physical and social artifacts, and through reflection shapes the character of individually held schemata.

Such a process of reflection is not necessarily conscious, explicit, or purposive (though it may be all three). Every experience implies a potential redefinition of preexisting schemata, whether the actor is capable of putting such an experience into words or not (Giddens 1979, p. 56–57). Analytically, any learning that is extracted from experience enters the individual intact and independent of preexisting learning. In parallel with the conversion of latent to empirical knowledge, this definition does not allow learning to exist in the objective sense because individuals and organizations cannot learn without the existence of a previous schema (Piaget 1980). So, by considering empirical knowledge as external and given, we neglect how the experiencing of physical and social artifacts is shaped by one's previous experiences.

We have discussed the two qualities of knowledge in organizations, latent and empirical, and the two processes by which they relate to one another, the conversion of latent to empirical knowledge and from empirical to latent knowledge. As we suggested, the concept of *organizational* knowledge can be understood only as the result of an ongoing, circular interaction between individually held latent knowledge and the knowledge manifest in the surrounding environments. It is only through this interaction that knowledge emerges as a social (and thus organizational) phenomenon. When this process unfolds in groups and organizations, knowledge is reproduced as it is made empirical in one person's actions and made latent again by another's experience of that action. From this perspective, the issue of interest is *how* knowledge is replicated in organizations because, under certain conditions, replication becomes autoreferential, and preexisting knowledge itself becomes the main obstacle to the development and acceptance of new ideas (Leonard-Barton 1992, Dougherty and Heller 1994). The challenge thus becomes understanding how to break these vicious circles, transforming them into patterns of interaction that enable and encourage the development of new ideas.

Applying a Complementary Perspective of Knowledge in Organizations

To ground the abstraction of a complementary model of knowledge, we use the findings of a field study of organizations whose knowledge-intensive practices reveal the interplay between latent and empirical knowledge. Previous research has identified a set of firms, knowledge brokers, that are involved in the creation of new knowledge by recognizing, recombining, and transferring past

knowledge (Hargadon and Sutton 1997, Davenport and Prusak 1998, Hargadon 1998). These organizations typically act in a consulting capacity, providing clients with project solutions in the form of new product or process designs and new business strategies or business systems. These organizations are not involved in the ongoing manufacture of similar products or the continuous replication of existing services. Rather, their routine, or at least expected, output is the generation of novel solutions. They are distinct from other organizations because they routinely innovate by introducing ideas in one domain that they have seen elsewhere, creating new combinations of ideas that few people, if any, have seen before. The work practices of these firms thus provide a particularly useful setting in which to ground the complementary model of knowledge and explore its dynamics.

The field research presented here draws from two such organizations: IDEO Product Development and Design Continuum. They are the two largest product development consultants in the United States, providing engineering and industrial design services to clients across the world and across a wide range of industries. Client organizations come to IDEO and Design Continuum seeking new and innovative product designs but bringing their own technical and manufacturing capabilities and (most often) specific project goals. IDEO Product Development began in 1978 and currently employs over 200 engineers and industrial designers who together have contributed to the development of over 4,000 new products for clients in over 40 industries. These products include the original Apple mouse, toy guitars, medical products the size of small automobiles, toothbrushes for kids, the mechanical whale in "Free Willy", and a bicycle water bottle. Design Continuum was founded in 1983 and currently employs over 100 engineers and industrial designers. Design Continuum's client list also spans hundreds of firms and dozens of industries, with products including the Reebok Pump shoe, an ultrasonic toothbrush, a modular (and adjustable) bathroom, a joystick for Sega gameplayer, a laproscopic device for surgeons, roller-blades, and silicon-wafer-handling robots.

This research used qualitative methods to gather data from multiple sources within each organization (Yin 1994). At IDEO, data were gathered through an intensive 18-month ethnographic study of the firm conducted by one of the authors together with Robert I. Sutton (see Sutton and Hargadon 1996).[4] In addition to observations of ongoing work, over the course of the study we tracked particular development projects, interviewed practically everyone in the firm, and observed over 24 brainstorming sessions and other meetings. At Design Continuum, evidence was gathered from five sources: observations of work, interviews with key informants, project postmortems, documents about the organization, and technological artifacts of the organization. Problem-solving meetings were observed in which groups faced problems and actively generated alternative solutions. Interviews were conducted with 12 informants ranging from the founder and current CEO to project managers and engineers. In addition to gaining the perspectives of organizational members, these interviews identified particular projects that served as "critical incidents" to focus discussions on behaviors and not impressions. Also based on these incidents, project postmortems were conducted in which teams gathered together to discuss the history of a recently completed project. Interviews and project postmortems identified past projects that reflected, in their outcomes, new combinations of existing ideas. From this, other individuals were interviewed to determine the source inspirations for the innovative features of the project and to explore what events brought these innovative ideas together. Written material and technical artifacts also served as data sources describing the work, structure, and culture of the organizations.

Work Within IDEO and Design Continuum

IDEO main offices are located in Palo Alto, California; Design Continuum is located just outside of Boston, Massachusetts. IDEO draws most of its engineers from nearby Stanford, where a number of its designers teach in the engineering school. Design Continuum draws most of its engineers from nearby MIT, where its designers sometimes teach. The engineers at IDEO and Design Continuum are predominantly young males, age 25–35, holding advanced degrees. Both companies have open floorplans, and the engineers and other designers work in cubicles that open into many common spaces. Both the cubicles and the common spaces are littered with artifacts: past projects, pieces of past projects, current prototypes, sketches of new ideas, engineering drawings, and a variety of toys, computers, and stereo equipment. On one desk at Design Continuum, for example, an assembled prototype of a new computer sits next to a Nerf™ rocket launcher, an antique wrench, pieces of a medical centrifuge from a past project, sketches of the new computer project, engineering books, and parts catalogs.

Work in these firms occurs in small teams ranging from two to five people (though projects may grow in size during peak efforts), and lasts from two months for small consumer items like pagers to two years or more for large medical products. Teams rarely remain together for longer than one or two projects. Because many people

have worked together before, the open office, and the visible nature of work, everyone tends to know what everyone else is working on and conversations about work tend to erupt spontaneously across current teams. Both offices had lively atmospheres in which designers had no hesitation in coming up to ask what we were doing, suggesting particular projects to look at, or demonstrating interesting new models, parts, or toys they had found.

One of the distinctive characteristics of IDEO and Design Continuum is their connection to a wide range of relatively disconnected knowledge domains and their ability to create new combinations of the ideas that exist in these different domains. David Kelley, CEO of IDEO, once said their strategy was to capitalize on IDEO's past experiences by bringing those old ideas to new domains, by "being the high-tech firm to low-tech firms." Further, a methodology handbook given to new IDEO employees states: "Working with companies in such dissimilar industries as medical instruments, furniture, toys, and computers has given us a broad view of the latest technologies, materials, and components available." And at Design Continuum, one manager described how "The range of our work is completely across the board. We continue to do medical products, consumer electronics, capital equipment, robotics. It's just a huge variety." This broad range of projects provides designers at IDEO and Design Continuum with a broad set of experiences to draw from when constructing new solutions. It also provides us with the opportunity to explore the recursive relationship between latent and empirical knowledge.

An Illustration of Knowledge in Action and Possibility

Because most organizations provide a relatively stable (and repetitive) context in which members carry out their work, it is hard to observe how old experiences become the potential for new possibilities. Repetition begets repetition. The innovation process, as it unfolds within IDEO and Design Continuum, offers us the opportunity to view the complementarity of knowledge in circumstances that are less stable and repetitive. For IDEO and Design Continuum engineers, their experiences in multiple knowledge domains enable them to create new knowledge when they see opportunities to use existing ideas learned in one domain to innovate in another. Difference begets difference.[5] By observing work in such firms, we have the opportunity to understand how members of an organization are able to generate new knowledge while simultaneously being constrained by what they have seen before. We begin by offering vignettes of innovative work in these firms.

• IDEO worked on a water-bottle project for Specialized™, a bicycle company wanting to offer accessory products that reflected their innovative stature in the market. Early in the project, the engineers recognized that they might be able to use a bistable valve design (that would stay closed in normal use, but automatically open when a user squeezed the bottle). This possibility was recognized by one designer who, three years earlier, created a shampoo bottle that used a similar valve. The resulting solution for Specialized™ was a product that combined a standard water bottle body with a valve design adapted from a shampoo bottle. Interestingly, this engineer mentioned how the idea for the shampoo bottle had come from a heart valve design someone on that team had seen earlier.

• Design Continuum developed a kitchen faucet for one client that incorporated three functions: normal flow, spray, and filtered water. Further, the removable handle included a charcoal filter and electronics to indicate its state. The complexity and new technologies in the product exceeded the experiences of their client. However, the engineers within Design Continuum had worked before with different valves and with microelectronics when designing medical products, washing machines, and consumer electronics products. When they presented these different valve designs, the client—who had been designing faucet valves for over 50 years—was awestruck. They knew what was in their industry, but had not seen what else was possible.

• While designing an ultrathin display housing for a portable computer, engineers at IDEO had "designed themselves into a corner." There was no room in the display housing to use inexpensive off-the-shelf fasteners. As a result, the product design required custom-made long, thin threaded fasteners that cost several dollars apiece. To make matters worse, these custom fasteners broke easily in assembling the prototype. Later, one engineer, an avid bicyclist, was studying the problem when he noticed that these custom fasteners looked very similar to the spokes of a bicycle wheel. Measuring the custom fastener, and the spokes on his bicycle, he discovered they were almost identical in diameter. As a result of this discovery, Wheelsmith™, a local wheel manufacturer, supplied spokes (cut to the right length) to the computer client for manufacturing the portable computer.

The theoretical models and methodologies of the organizational learning and innovation literatures offer differing accounts for the process of innovation observed at IDEO and Design Continuum. From a learning perspective, this process reflects the conversion of what members of an organization have seen previously into what they now know as possible (Huber 1991, Weick 1991). For

example, because one of IDEO's engineers had previously worked on a shampoo-bottle design, she could use this past experience to construct the solutions she proposed for the water-bottle valve. Yet, by emphasizing the adoption and reuse of ideas, a learning perspective neglects the importance of understanding how the organizational actors were able to redefine their schemata before seeing and producing something new. In other words, knowing what we now do, a shampoo bottle and bicycle water bottle seem similar. But to the engineers at the time, this similarity was not obvious and the solution for the water bottle was novel for the problem. From an innovation perspective, this phenomenon reflects the conversion of what an organization knows how to do (design a shampoo bottle) into what it does anew (design a bicycle water bottle). To their clients, for example, IDEO's water-bottle valve design and Design Continuum's valve and microelectronics designs were innovations. Yet to the engineers at IDEO and Design Continuum, these ideas were drawn from their past experiences. By emphasizing the creation of novel actions, an innovation perspective shifts attention away from the ways in which such actions are constructed from past ones. A complementary approach shifts the focus away from either learning or innovation and towards the interaction between them. In other words, a complementary perspective invites understanding of how the learning process changes the innovation process and how the innovation process changes the learning process.

Converting Action into Possibility, and Possibility into Action

While analytically distinct, in reality it is impossible to separate the cycle between empirical and latent knowledge. In other words, we can never truly know individually held schemata nor can we grasp the knowledge manifest in existing actions. We use people's actions to guess at what they have previously learned, and we use what they have previously learned to guess at what they might know how to do. It is not possible to know a priori what knowledge will be learned from past actions, or how it will be used (if at all) in constructing new actions. But it is possible to catch a glimpse of the ongoing cycle between empirical and latent knowledge, and how that cycle plays out in organizations, by looking at the innovations of IDEO and Design Continuum.

The novel actions of IDEO and Design Continuum engineers, for example, reveal some of the knowledge embedded in a previous shampoo-bottle design, in a heart valve, and in a washing machine, and how that knowledge provided the raw materials for what were very innovative solutions in bicycle water bottles and kitchen faucets. Firms such as IDEO and Design Continuum, by working with different clients organizations, expose their members to the knowledge that resides in the physical and social artifacts that make up their experiences with different client organizations. As one IDEO designer described, his diverse experiences made his memory "one big pile of tools" and while "each industry has its own set of tools. I only remember the tools, not where they came from." In this way, these diverse past experiences prove useful as organization members attempt to innovate.

Here, a complementary model of knowledge offers an insight into why latent knowledge appears at times to constrain innovative action and why, at other times, it appears to enable such actions. An organization profoundly shapes the environments, and hence experiences, of its members. Members of those client organizations that hire IDEO or Design Continuum often accumulate experience within only one or a few domains. Such a continuing cycle of action and experience within a single domain deepens the resemblance and mutual coherence between the knowledge residing in the social and physical artifacts of that domain and the latent knowledge held by its inhabitants, as when 50 years of experience within a single industry led members of the kitchen faucet company to think they knew everything they needed to know about their business. Wenger (1998) and Orr (1996) recognized this same coherence among individuals across organizations who share a common set of experiences with, for example, machines, and whose interactions around those machines produce a (relatively) common set of understandings. Within these stable networks of interaction (whether organizational or professional), individuals develop, over time, a stake in their shared latent knowledge. Deviations from expected action represent threatening shifts in previously established scripts, goals, or identities that will elicit responses, likely negative, from other participants in the ongoing process. The result is the apparent constraint that latent knowledge has on the generation of novel action.

For members of firms like IDEO and Design Continuum, that same knowledge enables novel actions when it provides the possibility for action in other domains. Experiences in multiple domains, and the resulting plurality of individual schemata, means that individual members place little stake in the reinforcement of any domain-specific knowledge they hold. For example, Design Continuum engineers found valuable ideas for a disposable wound-cleansing product in the design of supersoakers, the toy squirt guns that produce a high-pressure stream of water. Those designers, for the moment, had to see themselves as working on the same problems as designers

of a squirt gun. For engineers at the medical products company, such a shift might have been difficult given the coherence of their scripts, goals, and identities with the ongoing physical and social artifacts of the medical industry. For the Design Continuum engineers this shift was relatively easy because, a few years earlier, they had *been* the designers of such a squirt gun.

As a complementary view of knowledge suggests, this plurality of latent knowledge is not simply the possession of a range of "facts" but the presence and interaction of multiple schemata learned across different domains. When seen in contrast to the (relatively) narrower but deeper knowledge of client organizations, this plurality provides members of knowledge-brokering firms with latent knowledge that may be more flexible in its abilities to interpret problematic situations and recognize useful combinations of past ideas. Berger and Luckmann (1967, p. 125) argue that pluralism encourages both skepticism and innovation and is thus "inherently subversive of the taken-for-granted reality of the traditional status-quo." Further, Weick (1995, p. 24) argues that this pluralism resides within the individual as multiple identities that provide access to multiple schemas, suggesting "The more selves I have access to, the more meanings I should be able to impose in any situation." Within IDEO and Design Continuum, we find such a pluralism in the schemata of their members, providing them with the opportunity to consider a broader set of potentially relevant ideas.

Despite the plurality developed by working across domains, it bears mention that designers at IDEO or Design Continuum share common identities in other ways. For example, the nature of the relationship between these design firms and their clients create a role for individual designers *as* innovators who feel pressure to provide ideas that are new to their clients. Additionally, some willingly admitted that as mechanical engineers, they rarely suggest a problem could be solved better with, for example, software. And their common demographic background and especially education aligns their scripts, goals, and identities in ways that create a common culture without requiring (and even discouraging) conformity in their work-related knowledge. An IDEO designer reflected this attitude by admitting, "when you come to work and find someone else has your same coffee cup, or T-shirt, or even hobby, then it's time to get another one."

Discussion and Conclusion

The innovation process at IDEO and Design Continuum offers insights into how knowledge can both provide the raw material for novelty and constrain it. Knowledge resides in the latent knowledge—the schemas, goals, and identities of individuals in organizations—and in the concentration of artifacts and interactions that surround these individuals and comprise the organization. Repetitive cycles of interaction generate alignment between what people believe possible and confirmation of these beliefs in the actions (and sanctions) of others. Firms like IDEO and Design Continuum, by the variation in experiences faced by organizational members, avoid the cycle of action and experience that might reify similar knowledge in other organizations.

While the study of organizations like IDEO and Design Continuum provides glimpses of the complementarity of knowledge, a framework of the interaction between empirical and latent knowledge describes many instances of organizational knowledge and knowing. As Boland and Tenkasi stated (1995, p. 354), the "development of knowledge in a community is a process of posing and solving puzzles, thereby elaborating and refining the vocabulary, instruments, and theories that embody the perspective." The development of a process perspective is not the final goal of our study, but rather a means of explaining the dynamics of knowledge in organizations. The puzzle that raised our curiosity initially was the contradictory accounts that existing theories give to the phenomenon of organizational knowledge. Our answer, it should be underlined, is necessarily limited by our selection of the organizations studied and by the types of innovation and learning performed in these contexts. Nevertheless, we believe that some important conclusions, both for theory and practice, can be drawn.

First, a complementary perspective may explain why firms like IDEO and Design Continuum rely on clients to provide them with novel problems to work on. The plurality that enables novelty at IDEO and Design Continuum may simultaneously undermine the single-mindedness necessary to commit all of one's resources to a course of action. The lack of a single, overriding body of domain-specific latent knowledge, continually reinforced by surrounding experiences, makes it difficult for these actors to arrive at "the right thing to do" with its accompanying sense of satisfaction and confidence. Allowing Weick (1995, p. 24) to complete his argument for multiplicity, "furthermore, the more selves I have access to the less the likelihood that I will ever find myself surprised . . . or astonished . . ., although I may find myself confused by the overabundance of possibilities and therefore forced to deal with equivocality." In other words, knowledge brokers like IDEO and Design Continuum may need their clients for generating action as much as their clients need them for generating possibilities.

Second, a complementary perspective sheds new light on the different levels of analysis of knowledge and

knowing in organizations. The recursive processes of knowing become social when the knowledge manifested in one individual's action, by becoming a social artifact, shapes another individual's schema. Orr's (1996) description of copier technicians provides a rich example of how this cycle of action and interaction create (relatively) shared understandings about possible actions (scripts), desired ends (goals), and identities. In particular, the storytelling that occurs between technicians while "off the job" provides each with a better understanding of the work they do, the machines they tend to, and their own sense of their occupation and organization: "Each episode of machine repair is built on shared knowledge of earlier success and failures, and the stories that the technicians tell circulate that knowledge" (Orr 1996, p. 5). It may appear semantic, but in this sense "shared knowledge" refers not to knowledge that is commonly held (meaning identical) across technicians but rather knowledge that *has been shared* between technicians—knowledge made empirical through the generation of social artifacts, in this case stories, and made latent again through each individual's interpretation of those stories. We agree with Simon (1991, p. 125) and others that, "all learning takes place inside individual human heads," just as we agree with Boland and Tenkasi (1995, p. 335) that "the individual does not think in isolation and is not an autonomous origin of knowledge." From a complementary perspective, collective knowledge, whether at the level of groups or organizations, does not exist but rather refers to the recursive alignment of individually held schemas, goals, and identities.

So while it is tempting to call this relative alignment "common" or "shared" knowledge, such a language dilutes the critical differences between our individual understandings by suggesting that there is an objective reality that we could perceive and share, independent of our individual knowing processes. And such a language disguises the ongoing process that moves our understandings closer or farther apart. The process of knowing in organizations exists as a social phenomenon in the recursive social interactions between individuals. Group and organizational members come to hold (relatively) aligned interpretations of the world, (relatively) aligned goals, and (relatively) aligned identities because they tend to be surrounded by their own actions. It is the recursive interaction between latent and empirical knowledge—between possibility and action—that defines the concept of *organizational* knowledge.

Third, a complementary perspective of knowledge and knowing in organizations suggests other means by which organizations might overcome their established practices to generate novel solutions. Other strategies for managing innovation, for example, focus less on providing a diverse set of experiences—shaping the empirical knowledge that is available—and more on directly changing the goals or identities of the participants to enable them to see new possibilities. Lockheed's Skunkworks and Apple's Macintosh team are famous examples of new product development teams that have been isolated from the past practices, values, and expectations of the old organization and given new and different goals and identities for acting. Conversely, Leonard-Barton (1995) describes a strategy of "creative abrasion," which exploits the inherent differences based on the schemas, goals, and identities of different functional groups within an organization. This strategy generates novel actions by forcing interactions between diverse organizational members to elicit confrontation (and creative resolution) of their otherwise different perspectives on the world. Both of these strategies assume that the answers, in the form of latent knowledge, already reside to a large extent within the organization. These strategies are consistent with traditional conceptions of aligning individual member's goals and identities in order to achieve organizational ends. As Barnard states (1938, p. 279), the functions of the executive involve:

> . . . The process of inculcating points of view, fundamental attitudes, loyalties, to the organization or cooperative system, and to the system of objective authority that will result in subordinating individual interest and the minor dictates of personal codes to the good of the cooperative whole.

Yet as work processes at IDEO and Design Continuum show, strategies for managing knowledge in organizations need not focus only on managing and manipulating individual member's schemata. Equal attention by managers and researchers alike can be devoted to the role of social and physical artifacts from the surrounding environment in shaping the dynamics of individual and "organizational" knowing. For organizational members, cues in the environment invoke a particular schema which in turn shapes their interpretation and action—but to be perceived, those cues themselves must already reside within their existing latent knowledge. The generation of new knowledge or the successful replication of old knowledge depends not on the latent knowledge held by individuals nor the empirical knowledge of their surrounds, but rather on the cyclic interaction between the two, between the "energy" that resides in latent knowledge and the "matter" of empirical knowledge.

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Endnotes

[1]This distinction between empirical and latent qualities of knowledge—between views of knowledge as action and knowledge as the possibility for action—does not represent a taxonomy of knowledge, like Polanyi's distinction between tacit and explicit, but rather highlights different perspectives on the nature of knowledge.

[2]Process perspectives that recognize the essential recursivity of social life are long in lineage, having their roots in the "philosophy of process" of Whitehead, Bergson, and Hartshorne (Browning and Myers 1998). In addition to Giddens, the works of Bateson (1979) and Maturana and Varela (1987) share this perspective within the biological and cognitive sciences.

[3]And aside from the more purposive innovations, accidental discoveries often happen because of the recognition and reinterpretation of unexpected results, which often follow the misinterpretations or mistaken imitation of preexisting ideas.

[4]Hargadon and Sutton (1997) also used this ethnography as the basis for a paper on technology brokering. That paper contains additional information about IDEO's structure, work practices, norms, and values.

[5]Here we paraphrase Gregory Bateson's (1979) insight regarding the interaction between mind and nature in noting our perceptions are limited to those "differences that make a difference."

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