An adaptive strategy for managing knowledge in organizations

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Abstract

Purpose – *This article proposes an adaptive strategy for managing knowledge in complex organizations. Specifically, this article aims to extend understanding in the field of knowledge management (KM) by examining how an adaptive strategy for managing knowledge can help organizations become innovative and build dynamic capabilities.*

Design/methodology/approach – *Literature on complexity theory and KM is reviewed to propose the development of an adaptive strategy that will assist organization in managing knowledge and becoming innovative. The paper is structured around the following constructs: complexity theory, complex adaptive systems, and KM.*

Findings – *A link between an adaptive strategy for managing knowledge, innovation and dynamic capability is established. The central proposition of the article is the organizations that follow adaptive complex processes for managing knowledge are better able to compete in the market today.*

Research limitations/implications – *This article extends prior research on KM by proposing complexity theory as a framework for establishing adaptive strategies for managing knowledge and fostering innovation.*

Practical implications – *With the dramatic environmental changes and fierce competition that organizations are faced with today, managing knowledge becomes critical for driving creativity and adapting to changing markets. Organizations lack direction on how best to develop an adaptive strategy for managing knowledge. The revelation of adaptive processes for managing knowledge in complex systems can lead to more effective KM practices and a higher rate of creativity and flexibility.*

Originality/value – *The study answers recent calls for defining processes for the second generation of KM that shift focus from the codification and transfer of knowledge to the creation of new knowledge. Although previous studies have established a link between complex adaptive systems and KM, this study takes it one step further in defining an integrative strategy for the creation of knowledge based on the processes of complex adaptive systems. The paper provides a foundation for future studies to test the causal relationship between adaptive processes for knowledge creation and innovation.*

Keywords *Knowledge management, Adaptive system theory, Knowledge creation*

Paper type *Conceptual paper*

Introduction

Knowledge management (KM) has become a trademark for sustaining presence in continuously changing environments (Grant, 1996). The ability of organizations to integrate its intellectual assets to capitalize on their core competencies is the key to a sustained competitive advantage in the market. The increased focus on KM led organizations to introduce new roles and implement various KM technologies. New roles started to emerge like the chief knowledge officer (Davenport and Prusak, 1998) and knowledge workers (Schultze, 2000). Various technologies have been touted for the creation and maintenance of organizational memories, like portals, repositories and collaborative systems. These products are positioned as competitive forces for organizations to dominate in the knowledge economy. Despite the hype surrounding KM, it is not clear from previous studies

how organizations can manage knowledge in a way that will foster innovation and build dynamic capabilities.

In this study, complexity theory is proposed as a new theoretical lens to derive an adaptive strategy for managing knowledge. The emerging theory of complex systems focuses principally on how parts at a micro-level in a complex system affect emergent behavior and overall outcome at the macro-level. One distinguishing feature of a complex system is the ability of the parts to self-organize rather than being subdued by a central control. The parts are constantly seeking to improve performance driving the system away from equilibrium to the edge of chaos (Kaufman, 1993). What is of significance is how the parts co-adapt to improve their fitness and that of the system as a whole.

Most of the earlier studies on KM did not focus on identifying and studying how organizations can integrate pieces of knowledge to foster innovation. However, some were able to deduce that failure to manage knowledge is a result of the inability of some organizations to realize the effect of the interaction between elements of the infrastructure (Gold *et al.*, 2001; McDermott, 1999; Schultze and Boland, 2000).

The main objectives of this study are to identify the nature and characteristic of the interrelationships that can exist between pieces of knowledge within an organization and the effect of these relationships on the innovation-rate and performance of the whole system. In this study, the focus is on defining an adaptive strategy that allow for easy integration of the various specialized knowledge within the organization through a set of processes for capturing, integrating and applying knowledge. In particular the research attempts to answer the question of how an adaptive strategy for managing knowledge can foster innovation and build dynamic capabilities.

The paper is organized as follows. The following section defines the nature of adaptive complex systems; the next section explains the different adaptive processes for managing knowledge in a complex adaptive system; the third section discusses the implications of these processes for a KM strategy; and the fourth section concludes with implications of the study to research and practice.

Adaptive complex systems

Complex adaptive systems (CAS) is a term coined by Holland (1975) to describe ''nonlinear systems'' whose behavior is determined by the interaction of its adaptive parts. The numerous parts that make up the structure and the level of interaction that exists between the parts are the main distinguishing features of a complex system. The complexity of the system stems from the collective control that the parts exert on the whole. Although each part is governed by a set of simple rules, the interaction between the parts emerge complex patterns of behavior (Kurtz and Snowden, 2003). The lack of a central control unit makes it hard to determine the attribution of any one part to the performance of the whole. This is primarily because of the confounding effect of a change in one part on other parts and the whole. An interesting implication of the structure of a complex system is that a sub-optimal behavior of some of the parts may be the only means to optimize the behavior of the whole (Kurtz and Snowden, 2003).

The adaptation of the system and the parts allow structures within the system to progressively change to improve its performance in its environment. The concept is borrowed from natural science's stand on the role of evolution in producing increasingly fit organisms within different environments. As such the adaptive processes are seen as optimization processes that progressively modify structures within a system in an attempt to ''get an edge''. The most intriguing phase is at the point at which new behaviors inexplicably emerge in response to change (McElroy, 2003), a phase believed to be between order and chaos (Kaufman, 1993).

Adaptation of complex systems is governed by an adaptive plan. The plan determines which structure within the system to change and what structural operators to apply to make the structure and the whole system better fit in the environment in which it exists. Structures that enhances the system's performance are stabilized and repeated and those that fail to

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adequately respond to changes in the environment are rejected (McElroy, 2003). The adaptive plan evolves over time as the system has multiple interactions within its environment and generates and tests the different structures (Holland and Miller, 1991). The plan must retain its earlier successes in generating structures that are fit to deal with the environment as well as portions of its history that captures the ''plan-environment interaction.'' The plan uses both to increase its chances of success in generating new structures, which will improve the performance of the system as a whole in the environment in which it operates.

Organizations as complex systems

Out of research on complex adaptive systems came complexity theory (Gell-Mann, 1994; Kaufman, 1993). Organizational theorists have recently started using complexity theory to explain the behavior of some organizations in coping with continuous change (Brown and Eisenhardt, 1997; Brown and Eisenhardt, 1998; Levinthal, 1997; McKelvey, 1999). Organizations are perceived as a complex system of interrelated agents. Agents can be individuals, groups, processes, technology, or even specialized knowledge. The agents influence and are influenced by the interaction among them and interaction with the environment (Holland and Miller, 1991). The ability of organizations to change rapidly in response to intra and inter relationships is at the heart of an adaptive organization (Brown and Eisenhardt, 1997); an organization whose behavior is complicated and unpredictable (Brown and Eisenhardt, 1998). Furthermore, the relationships between cause and effect cannot be determined and actions are not deliberate.

Complexity theory offers an appealing lens for viewing and analyzing KM strategies (McElroy, 2003). The concept that higher-level order of a complex system emerges out of the low-level interactions of the autonomous parts is an apposite metaphor of the dynamics of a KM strategy. The performance of the whole is exceedingly dependent on the interaction of the parts rather than on the idiosyncratic performance of any one part. In fact the progress of one part drives progress in other related parts.

Most studies on KM have successfully defined major parts of the system that contribute to the success of the whole program. Strategies are put in place to give meaning and significance to KM practices for creating, assimilating, disseminating, and protecting knowledge (Alavi and Leidner, 1999; Massey *et al.*, 2002). Strategies reinforce these practices and ensure their implementation throughout the organization. Based on the strategy, KM will determine the processes for managing knowledge. KM processes define methods for managing knowledge at a macro (organizational) and micro (individual and group) level. The processes specifically focus on facilitating the creation of knowledge at the individual and group level and selectively applying those that become associated with favorable outcomes. The processes of creating, categorizing, retrieving, abstracting, and adapting knowledge assets constitute the majority of day-to-day activities of a KM program. An organization may focus on one process over others depending on the type of knowledge to be managed and the degree of change that renders knowledge assets obsolete (Hansen *et al.*, 1999). Tacit knowledge is best leveraged through social interaction (Nonaka and Takeuchi, 1995), whereas explicit knowledge can be codified, captured, and disseminated electronically (Huang, 1998). Organizations that operate in a highly volatile environment, where domain knowledge is subject to self-cancellation, tend to attach more importance to experimentation (Garvin, 1993) and synthesis of expertise rather than to transfer of knowledge (Quinn *et al.*, 1996).

A key realization of the second generation KM is that a best practice is only appropriate as long as old patterns continue to exist. A best practice can become obsolete as changes in the environment bring about a shift in focus (from a prominent technology to an emergent new one; a technology that may shed light on another piece of knowledge that gain significance only in retrospect). The tension between the stabilized and the emergent is seen as a stimulant for innovation and creativity (McElroy, 2003; Kurtz and Snowden, 2003). Such a ''constructive non-conformity'' is a significant source of power for organizations.

Very few studies referred to the importance of defining a flexible strategy for KM that acknowledges the interrelationships between the elements and the need to support the emergence of new processes in response to change. Schultze (2000) report lack of understanding of situated work practices as one of the reasons responsible for the failure of KM systems. Sherif and Mandviwalla (2000) unveil a number of organizational skepticism regarding the currency and applicability of information residing within KMS. Scott (2000) realizes that the effectiveness of IT in actualizing KM and organizational learning is significantly dependent on sustaining trust. El Sawy and Bowles (1997) stress the impact of external factors on affecting the efficacy of KM initiatives.

McElroy (2003) and Snowden (2002) are among the few who made direct connections between complexity and knowledge management drawing attention to the interplay between the elements of the KM strategy and the changes in the relationships between the elements and the environment. They both stressed the importance of making the strategy adaptable enough to embrace change and thus support knowledge creation. However the micro processes that make up that adaptive strategy for managing knowledge are not clearly defined.

In this paper, the focus of investigation is on KM strategies that support the creation of new knowledge. Though knowledge creation is considered the most important of all KM processes (Lapre and Van Wassenhove, 2001), current understanding of the micro-processes is fairly limited. The general belief is that knowledge creation is an inherent trait of some organizations, an art of continuous change (Brown and Eisenhardt, 1998) that the majority of organizations may fail to imitate (Quinn *et al.*, 1996). While some attempted to systematize the process of knowledge creation into a set of explicit but overlapping phases (Garvin, 1993), the majority conquer with the proposition that the process is highly tacit and cannot be captured. Borrowing from the literature on complex adaptive systems (CAS), a set of processes for managing knowledge creation in organizations is defined.

Knowledge creation in complex adaptive systems

The study of CAS was first introduced by the Santa Fe Institute in an attempt to provide a radically new perspective to the dynamics of complex systems. A CAS is composed of a large number of interacting agents that are diverse in form and ability (Holland, 1975). The system derives its complexity from the diversity of, and the level of interaction between agents. The higher the number of agents and the higher the level of interaction between them, the harder it is to predict the system's behavior (Kaufman, 1993). While agents act according to their own best interest, they collaboratively cause the system to move in a certain direction, which may be hard to predict.

Over time, the extensive interaction between the various agents determines the behavior of the overall system within its environment. The agents learn from these interactions and restructure themselves to better adapt to the environment (Levinthal, 1997). The behavior of the individual agent in interacting with other agents or with the environment is determined by a collection of rules. The rules serve as strategies that define responses for the different stimuli initiated by other agents or triggered by the environment (Gell-Mann, 1994).

Agents depend on several mechanisms to guide their interaction with other agents in the system and with the environment. Tagging is a mechanism that supports agents to selectively interact with others in the system (Holland, 1975). Depending on the tags

attached to an agent, others may initiate a request for collaboration to perform complex tasks. These collaborations enable the evolution of an individual agent's behavior from simple ones to complex ones. In due time, an agent can evolve to be a conglomerate of agents which is a hierarchical structure that allocates resources to specialized but cooperating agents. Agents in a multi-agent hierarchy specialize based on their form and capacity (Kaufman, 1993). The networked intelligence of agents enables the CAS to innovate. Depending on the overall performance of the multi-agent, higher-level survival is determined (Kaufman, 1993). Unfit agents are removed from the structure as superior agents supersede them.

Management of knowledge

An adaptive agent utilizes its internal model to interact and adapt. As mentioned earlier, agents react to their environment by recognizing the relationship between a stimulus and a certain response (Gell-Mann, 1994). While no two scenarios are exactly identical until abstracted to some degree, agents can recognize patterns and generate rules that assist them to anticipate consequences in the future when the same pattern recurs. The ability to recognize patterns depends on their ability to capture past experience and induce rules from the recurring patterns abstracted from experiences (Gell-Mann, 1994). Some of the knowledge gained from experience is codifiable and specific, lowering the cognitive complexity required for generating a rule. Tacit and abstract knowledge make it cognitively complex for the CAS to generate new rules as it becomes harder to draw analogies to past experience (Holland, 1975). It takes more than one occurrence for the pattern to cause the CAS to generate a rule.

Over time the rules aggregate to form the building blocks of the agent's internal model (Kaufman, 1993). The model helps the agent avoid undesirable situations. It also enables the agent to secure necessary resources for survival by offering above-average responses to internal and external stimuli. As agents interact with other agents or the environment, they put their mental models to test. Because of their intrinsic drive to improve their ability and performance, agents make structural changes to their models, a process known as adaptation. During this process, the rules act like competing hypotheses that undergo test and confirmation. The usefulness of a rule depends on its ability to accurately identify a specific response for a current stimulus (Levinthal, 1997). Rules compete to gain credit depending on their level of accuracy and specificity. Over time, agents modify the structure of their internal models through discrimination, replacing general rules with specific ones and adding new rules to fill in gaps, thus forming a default hierarchy. Such process of adaptation is a rule discovery process in which the plausibility of generated rules is tested and their ability to combine and formulate new building blocks is explored.

The environment is another source of stimuli for a CAS. It dictates the change the CAS must react to (Holland and Miller, 1991). A CAS, in general, is always in pursuit of the highest peak on its fitness landscape (Levinthal, 1997). Smooth landscapes are characterized by stability and predictability because of the limited interaction between the agents. The smoothest landscapes have one peak that defines the optimum performance, and thus, it is relatively easy for agents to locate the peak. A CAS that emerges from smooth landscapes tends to exploit internally formulated rules to better adapt to the environment. Given time, the CAS is likely to reach the peak depending on its agents' ability to discriminate. A CAS that emerges from rugged landscapes, on the other hand, undergoes continuous change. An agent's search for the peak is, to a great extent, contingent on the behavior of other agents. A

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rugged landscape is likely to give rise to a CAS whose behavior is unpredictable because of the high degree of change it has to respond to. The CAS in a rugged environment is also characterized by a high degree of interdependency between the agents, which results in multiple peaks on the fitness landscape. The broad but loosely structured coalition of agents enables the CAS to manage a complex and uncertain environment by providing multiple perspectives for the same situation and better opportunities for remote and external information to be incorporated. The advantage allows the interaction among agents to trigger the birth of new knowledge that may cause the height of one or more peaks to change with respect to others on the rugged landscape. In both environments, the agents continuously search for ways to improve their local fitness within the environment. The cyclical disruption of local rules may originate from the environment or may be self-provoked for innovative purposes. Agents enforce, discard, aggregate, and generalize rules to avoid being trapped in a solution space that outlives its value-generating span.

Beside the exploitation of local rules, agents may resort to neighboring settings to explore new rules in an attempt to improve fitness; this process is known as a long jump. Long jumps are possible when the agents within the system are loosely coupled and can explore knowledge gained in neighborhood setting by relaxing some of the specific rules (Levinthal, 1997). The boundary transitions may also challenge entrained rules, causing the system to reassess and reorganize its own knowledge base. It is through the exploration and space probing that new innovations are discovered in a relentless struggle to improve performance. In multiple industries, many breakthroughs were discovered by drawing on disciplines from neighboring fields.

Implications for KM

Organizational innovations are iterative and build on already existing wellsprings of knowledge (Leonard-Barton, 1995). The majority of organizations capture past experiences and lessons learnt on different engagements. However, innovative organizations go beyond codifying and disseminating knowledge. They do not rest on the laurels of best practices and lessons learned but are continuously evolving new ones. Their organizational memories have a very fluid structure where knowledge assets are added, deleted, and restructured on a continuous basis. The disruption of the structure of the memory would be an inherent process that the knowledge workers engage in to sustain the interest of the organization in knowledge creation.

The knowledge assets that innovative organizations manage at any point in time differ in specialty and structure. A leading software developing company, for example, has knowledge assets in the form of deliverables, best practices, and standards for developing the user interface. Each, obviously, has a different purpose. More importantly, they represent knowledge assets at different levels of abstraction. The deliverables are specific and detailed; best practices are filtered deliverables that have been associated with favorable outcomes; and standards and methods are aggregated but abstracted best practices. The emergence of best practices and standards and methods is only possible after the organization has had similar encounters in a specific domain. It is only after a pattern stabilizes that the organization is able to determine which actions are associated with favorable outcomes.

An important realization of the innovative organization is that a number of knowledge assets can emerge to be best practices in retrospect. In exploring the possibility of emerging a new best practice, the innovative organization draws relationships between the different knowledge assets; the same relationships that you would expect between classes in a class model. Some assets may be associated in one-to-one, one-to-many, and many-to-many relationships. Others may be consumed in an aggregation of multi-asset structure or shared among many aggregations. Continuing on the earlier example, a use-case is expected to be associated with a number of interactive models to allow for requirement traceability. Depending on the accuracy and level of detail of a particular deliverable, it can be generalized and abstracted to more than one context. Given the high level of connectivity

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between the assets, the organization is able to generate an innumerable number of solutions, each of which is logical in a specific context and at a specific period of time.

Like agents in a true CAS, knowledge workers need to push knowledge assets outside their domain of origin and challenge the entrained thinking of the various professional communities, a process known as abrasive creativity. The transition of knowledge across boundaries is likely to create friction between the different schools of thought and generate new perspectives and emerge new knowledge. The disruption of entrained thinking should be cyclical rather than anecdotal motivated by a commitment to create a true learning organization.

Adaptive processes for managing knowledge

The ability of the innovative organization to exploit its past depends on its ability to recall it. Organizations need to tag knowledge assets to associate them with a domain, a specific functionality, and a level of abstraction. Knowledge assets need tags to facilitate the process of linking them to other knowledge assets. A knowledge asset may be a generalization or a specialization of another, like the best practices are an abstraction of the lessons learned from multiple deliverables. A knowledge asset may be part of another, like a description and a diagram that are parts of a model. By drawing relationships between knowledge assets, organizations can create new knowledge from knowledge already captured in a repository.

New knowledge gained needs to be assessed relative to what already exists within the repository. The new knowledge asset may become part of a hierarchy of knowledge assets as it fills a gap within the structure, a case of aggregation; the new knowledge may provide more insights into a process by providing more details, an example of specialization; or it may abstract knowledge that already exists to increase the level of reuse across domains, a case of generalization. As new knowledge is assimilated, new relationships are defined and old ones maybe modified or broken all together.

Generalizing knowledge assets by identifying commonalities increase the probability of reuse outside the original domain. It is the cross-fertilization of domains (long jumps) where general knowledge asset are applied outside their domain, that new knowledge is created. Specialization, on the other hand, enables organizations to complement general knowledge assets with more specific assets. As the organization encounters new cases in a specific domain, it is likely that it gains depth and is able to discriminate against pieces of knowledge and create rules of when a specialized knowledge would better apply than the general or other specialized versions.

As knowledge assets are applied to new situations, feedback should be collected on the perception of the strength and specificity of the assets. Only fit knowledge assets should be kept. Knowledge asset that are incapable of accurately defining a course of action for a specific situation lose the interest of the knowledge workers. Without feedback and evaluation, it becomes very problematic to emerge new knowledge as organizations interpret any new experience as an account of its past, reacting in the same way as it did before.

To a large extent, the process of innovation is incremental and significantly relies on knowledge gained in the past. The greater the diversity and scope of the knowledge assets within the knowledge repository, the higher the possibility of generating new knowledge through aggregation, specialization, generalization or cross-fertilization across domains. The process of creating new knowledge requires that organizations engage in creative thinking and reflection on past experience (Quinn *et al.*, 1996). Through reflection, organization may create new knowledge assets that aggregate a number of smaller ones in

an effort to emerge a comprehensive business process. Comparisons of similar assets may result in eliminating redundancies or declaring some as specific to certain conditions. Higher benefits can also be achieved from the cross fertilization of ideas across domains (Nonaka and Takeuchi, 1995).

Implications

The insights offered by this study will prove useful to both scholars interested in studying KM and to practitioners responsible for the activities and practices of KM within organizations.

Research focused on understanding the implementation of KM should benefit from an enriched appreciation of the adaptive processes of complex adaptive systems. These adaptive processes reflect episodes of massive organizational learning, which must be orchestrated and supported by time and resources. The findings will enable practitioners to better plan and carryout KM programs to radically improve organizational learning through the application of complex adaptive processes. In particular, four observations seem most important:

1. *New knowledge must be linked to already existing knowledge and the relationship must be defined.* It is crucial to understand how new knowledge relate to existing information, what gaps it fills, and where best to apply it.
2. *From time to time, best practices and lessons learned need to be abstracted so that knowledge can be applied across domains.* Abstracting knowledge would get rid of contextual information that tie knowledge to a specific domain and generalize so other units can find ways of benefiting from it.
3. *Successful KM programs demand, at their core, active attention to feedback.* By its nature, KM involves learning from experience. Such learning requires that organizations collect feedback on the performance of the knowledge assets. As a consequence, resources and time must be invested in learning activities, and the learning that occurs must be fed back into the work processes.
4. *A best practice is only good in a specific situation; other knowledge assets may emerge to be best practices in retrospect.* It is critical for an innovative organization not to forcefully entrench best practices, but to realize that any change in the experience may render the best practices obsolete. Innovative organizations must be constantly in search for the best practice, cross-fertilizing knowledge across domains in an effort to create new knowledge.

References

Alavi, M. and Leidner, D.E. (1999), ''KM systems: issues, challenges and benefits'', *Communications of AIS*, Vol. 1, pp. 1-37.

Brown, S.L. and Eisenhardt, K.M. (1997), ''The art of continuous change: linking complexity theory and time-paced evolution in relentlessly shifting organizations'', *Administrative Science Quarterly*, Vol. 42 No. 1, pp. 1-34.

Brown, S.L. and Eisenhardt, K.M. (1998), *Competing on the Edge: Strategy as Structured Chaos*, Harvard Business School Press, Boston, MA.

Davenport, T.H. and Prusak, L. (1998), *Working Knowledge: How Organizations Manage What They Know*, Harvard Business School Press, Boston, MA.

El Sawy, O. and Bowles, G. (1997), ''Redesigning the customer support process for the electronic economy: insights from storage dimensions'', *MIS Quarterly*, Vol. 21 No. 4, pp. 457-83.

Garvin, A.D. (1993), ''Building a learning organization'', *Harvard Business Review*, Vol. 74 No. 4, p. 78.

Gell-Mann, M. (1994), *The Quark and the Jaguar: Adventures in the Simple and the Complex*, W.H. Freeman, New York, NY.

Gold, A., Malhotra, A. and Segars, A. (2001), ''KM: an organizational capabilities perspective'', *Journal of Management Information Systems*, Vol. 18 No. 1, pp. 185-214.

Grant, R.M. (1996), ''Toward a knowledge-based theory of the firm'', *Strategic Management Journal*, Vol. 17, p. 109.

Hansen, M.T., Nohria, N. and Tierney, T. (1999), ''What's your strategy for managing knowledge?'', *Harvard Business Review*, Vol. 77 No. 2, p. 106.

Holland, J.H. (1975), *Adaptation in Natural and Artificial Systems*, The MIT Press, Cambridge, MA.

Holland, J.H. and Miller, J.H. (1991), ''Artificial adaptive agents in economic theory'', *American Economic Review*, Vol. 81 No. 2, pp. 365-70.

Huang, K.T. (1998), ''Capitalizing on intellectual assets'', *IBM Systems Journal*, Vol. 37 No. 4, p. 570.

Kaufman, S.A. (1993), *The Origins of Order: Self Organization and Selection in Evolution*, Oxford University Press, New York, NY.

Kurtz, C.F. and Snowden, D.J. (2003), ''The new dynamics of strategy: sense-making in a complex and complicated world'', *IBM Systems Journal*, Vol. 42 No. 3, pp. 462-83.

Lapre, M.A. and Van Wassenhove, L.N. (2001), ''Creating and transferring knowledge for productivity improvement in factories'', *Management Science*, Vol. 47 No. 10, pp. 1311-25.

Leonard-Barton, D. (1995), *Building and Sustaining the Source of Innovation*, Harvard Business School Press, Boston, MA.

Levinthal, D.A. (1997), ''Adaptation on rugged landscapes'', *Management Science*, Vol. 43 No. 7, pp. 934-50.

McDermott, R. (1999), ''Why information technology inspired but cannot deliver knowledge management'', *California Management Review*, Vol. 41 No. 4, pp. 103-17.

McElroy, M. (2003), *The New Knowledge Management: Complexity, Learning, and Sustainable Innovation*, KMCI Press, Boston, MA.

McKelvey, B. (1999), ''Avoiding complexity catastrophe in coevolutionary pockets: strategies for rugged landscapes'', *Organization Science*, Vol. 10 No. 3, pp. 294-321.

Massey, A.P., Montoya-Weiss, M.M. and O'Driscoll, T. (2002), ''Knowledge management in pursuit of performance: insights from Nortel Networks'', *MIS Quarterly*, Vol. 26 No. 3, pp. 269-89.

Nonaka, I. and Takeuchi, H. (1995), *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation*, Oxford University Press, New York, NY.

Quinn, J.B., Anderson, P. and Finkelstein, S. (1996), ''Managing professional intellect: making the most of the best'', *Harvard Business Review*, Vol. 74 No. 2, pp. 71-81.

Schultze, U. (2000), ''A confessional account of an ethnography about knowledge work'', *MIS Quarterly*, Vol. 24 No. 1, pp. 3-41.

Schultze, U. and Boland, R.J. (2000), ''Knowledge management technology and the reproduction of knowledge work practices'', *Journal of Strategic Information Systems*, Vol. 9, pp. 193-212.

Scott, J.E. (2000), ''Facilitating interorganizational learning with information technology'', *Journal of Management Information Systems*, Vol. 17 No. 2, pp. 81-113.

Sherif, K. and Mandviwalla, M. (2000), ''Barriers to actualizing organizational memories lessons from industry'', *proceedings of the 33rd Annual Hawaii International Conference on System Sciences*, 2000, p. 68.

Snowden, D. (2002), ''Complex acts of knowing: paradox and descriptive self awareness'', *Journal of Knowledge Management*, Vol. 6 No. 2, pp. 100-12.

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