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REVIEW: KNOWLEDGE MANAGEMENT AND KNOWLEDGE MANAGEMENT SYSTEMS: CONCEPTUAL FOUNDATIONS AND RESEARCH ISSUES[1, 2]

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Abstract

Knowledge is a broad and abstract notion that has defined epistemological debate in western philosophy since the classical Greek era. In the past few years, however, there has been a growing interest in treating knowledge as a significant organizational resource. Consistent with the interest in organizational knowledge and knowledge management (KM), IS researchers have begun promoting a class of information systems, referred to as knowledge management systems (KMS). The objective of KMS is to support creation, transfer, and application of knowledge in organizations. Knowledge and knowledge management are complex and multi-faceted concepts. Thus, effective development and implementation of KMS requires a foundation in several rich literatures.

To be credible, KMS research and development should preserve and build upon the significant literature that exists in different but related fields. This paper provides a review and interpretation of knowledge management literatures in different fields with an eye toward identifying the important areas for research. We present a detailed process view of organizational knowledge management with a focus on the potential role of information technology in this process. Drawing upon the literature review and analysis of knowledge management processes, we discuss several important research issues surrounding the knowledge management processes and the role of IT in support of these processes.

In post-capitalism, power comes from transmitting information to make it productive, not from hiding it.

Drucker 1995

Introduction

A knowledge-based perspective of the firm has emerged in the strategic management literature (Cole 1998; Spender 1996a, 1996b; Nonaka and Takeuchi 1995). This perspective builds upon and extends the resource-based theory of the firm initially promoted by Penrose (1959) and expanded by others (Barney 1991; Conner 1991; Wernerfelt 1984).

The knowledge-based perspective postulates that the services rendered by tangible resources depend on how they are combined and applied, which is in turn a function of the firm's know-how (i.e., knowledge). This knowledge is embedded in and carried through multiple entities including organization culture and identity, routines, policies, systems, and documents, as well as individual employees (Grant 1996a, 1996b; Nelson and Winter 1982; Spender 1996a, 1996b). Because knowledge-based resources are usually difficult to imitate and socially complex, the knowledge-based view of the firm posits that these knowledge assets may produce long-term sustainable competitive advantage. However, it is less the knowledge existing at any given time per se than the firm's ability to effectively apply the existing knowledge to create new knowledge and to take action that forms the basis for achieving competitive advantage from knowledge-based assets. It is here that information technologies may play an important role in effectuating the knowledge-based view of the firm. Advanced information technologies (e.g., the Internet, intranets, extranets, browsers, data warehouses, data mining techniques, and software agents) can be used to systematize, enhance, and expedite large-scale intra- and inter-firm knowledge management.

Although the concept of coding, storing, and transmitting knowledge in organizations is not new—training and employee development programs, organizational policies, routines, procedures, reports, and manuals have served this function for years (Alavi and Leidner 1999)—organizational and managerial practice has recently become more knowledge-focused. For example, benchmarking, knowledge audits, best practice transfer, and employee development point to the realization of the importance of organizational knowledge and intangible assets in general (Grant 1996a, 1996b; Spender 1996a, 1996b). Given the importance of organizational knowledge, our objective is to synthesize the relevant and knowledge-centered work from multiple disciplines that in our view contribute to and shape our understanding of knowledge management and knowledge management systems in organizations.

The paper is organized as follows: the next section presents a review of the management literature on knowledge and the firm. This section provides a comprehensive summary of alternative views of knowledge and knowledge taxonomies and their implications for knowledge management. The following section adopts the process view of knowledge management and presents this view in detail with an eye toward identifying the potential role of information technologies in the various stages of the knowledge management process. A broader organizational perspective on knowledge management research is then provided by discussing important research themes that emerge from the review of the literature. The final section provides a summary and presents the discussion of the four general conclusions of our work.

Knowledge and the Firm: An Overview and Basic Concepts

The question of defining knowledge has occupied the minds of philosophers since the classical

Greek era and has led to many epistemological debates. It is unnecessary for the purposes of this paper to engage in a debate to probe, question, or reframe the term knowledge, or discover the "universal truth," from the perspective of ancient or modern philosophy. This is because such an understanding of knowledge was neither a determinant factor in building the knowledge-based theory of the firm nor in triggering researcher and practitioner interest in managing organizational knowledge. It is, however, useful to consider the manifold views of knowledge as discussed in the information technology (IT), strategic management, and organizational theory literature. This will enable us to uncover some assumptions about knowledge that underlie organizational knowledge management processes and KMS. We will begin by considering definitions of knowledge.

The Hierarchical View of Data, Information, and Knowledge

Some authors, most notably in IT literature, address the question of defining knowledge by distinguishing among knowledge, information, and data. The assumption seems to be that if knowledge is not something that is different from data or information, then there is nothing new or interesting about knowledge management (Fahey and Prusak 1998). A commonly held view with sundry minor variants is that data is raw numbers and facts, information is processed data, and knowledge is authenticated information (Dreske 1981; Machlup 1983; Vance 1997). Yet the presumption of a hierarchy from data to information to knowledge with each varying along some dimension, such as context, usefulness, or interpretability, rarely survives scrupulous evaluation. What is key to effectively distinguishing between information and knowledge is not found in the content, structure, accuracy, or utility of the supposed information or knowledge. Rather, knowledge is information possessed in the mind of individuals: it is personalized information (which may or may not be new, unique, useful, or accurate) related to facts, procedures, concepts, interpretations, ideas, observations, and judgments.

Tuomi (1999) makes the iconoclastic argument that the often-assumed hierarchy from data to knowledge is actually inverse: knowledge must exist before information can be formulated and before data can be measured to form information. As such, "raw data" do not exist—even the most elementary piece of "data" has already been influenced by the thought or knowledge processes that led to its identification and collection. Tuomi argues that knowledge exists which, when articulated, verbalized, and structured, becomes information which, when assigned a fixed representation and standard interpretation, becomes data. Critical to this argument is the fact that knowledge does not exist outside of an agent (a knower): it is indelibly shaped by one's needs as well as one's initial stock of knowledge (Fahey and Prusak 1998; Tuomi 1999). Knowledge is thus the result of cognitive processing triggered by the inflow of new stimuli. Consistent with this view, we posit that information is converted to knowledge once it is processed in the mind of individuals and knowledge becomes information once it is articulated and presented in the form of text, graphics, words, or other symbolic forms. A significant implication of this view of knowledge is that for individuals to arrive at the same understanding of data or information, they must share a certain knowledge base. Another important implication of this definition of knowledge is that systems designed to support knowledge in organizations may not appear radically different from other forms of information systems, but will be geared toward enabling users to assign meaning to information and to capture some of their knowledge in information and/or data.

Alternative Perspectives on Knowledge

Knowledge is defined as a justified belief that increases an entity's capacity for effective action (Huber 1991; Nonaka 1994). Knowledge may be viewed from several perspectives (1) a state of mind, (2) an object, (3) a process, (4) a condition of having access to information, or (5) a capability.

Knowledge has been described as "a state or fact of knowing" with knowing being a condition of "understanding gained through experience or study; the sum or range of what has been perceived, discovered, or learned" (Schubert et al. 1998). The perspective on knowledge as a state of mind focuses on enabling individuals to expand their personal knowledge and apply it to the organization's needs. A second view defines knowledge as an object (Carlsson et al. 1996; McQueen 1998; Zack 1998a). This perspective posits that knowledge can be viewed as a thing to be stored and manipulated (i.e., an object) Alternatively, knowledge can be viewed as a process of simultaneously knowing and acting (Carlsson et al. 1996; McQueen 1998; Zack 1998a). The process perspective focuses on the applying of expertise (Zack 1998a). The fourth view of knowledge is that of a condition of access to information (McQueen 1998). According to this view, organizational knowledge must be organized to facilitate access to and retrieval of content. This view may be thought of as an extension of the view of knowledge as an object, with a special emphasis on the accessibility of the knowledge objects. Finally, knowledge can be viewed as a capability with the potential for influencing future action (Carlsson et al. 1996). Watson (1999) builds upon the capability view by suggesting that knowledge is not so much a capability for specific action, but the capacity to use information; learning and experience result in an ability to interpret information and to ascertain what information is necessary in decision making.

These different views of knowledge lead to different perceptions of knowledge management (Carlsson et al. 1996). If knowledge is viewed as an object, or is equated with information access, then knowledge management should focus on building and managing knowledge stocks. If knowledge is a process, then the implied knowledge management focus is on knowledge flow and the processes of creation, sharing, and distribution of knowledge. The view of knowledge as a capability suggests a knowledge management perspective centered on building core competencies, understanding the strategic advantage of know-how, and creating intellectual capital. The major implication of these various conceptions of knowledge is that each perspective suggests a different strategy for managing the knowledge and a different perspective of the role of systems in support of knowledge management.

Table 1 summarizes the various views of knowledge just discussed and their implications for knowledge management and knowledge management systems. The perspective relied upon most heavily in this article is that implied in the distinction of knowledge from data and information, closely related to the perspective of knowledge as a state of mind.

Summary of Knowledge Perspective

Three major points emerge from the above discussion: (1) A great deal of emphasis is given to understanding the difference among data, information, and knowledge and drawing implications from the difference. (2) Because knowledge is personalized, in order for an individual's or a group's knowledge to be useful for others, it must be expressed in such a manner as to be interpretable by the receivers. (3) Hoards of information are of little value; only that information which is actively processed in the mind of an individual through a process of reflection, enlightenment, or learning can be useful.

Taxonomies of Knowledge

Drawing on the work of Polanyi (1962, 1967), Nonaka (1994) explicated two dimensions of knowledge in organizations: tacit and explicit. Rooted in action, experience, and involvement in a specific context, the tacit dimension of knowledge (henceforth referred to as tacit knowledge) is comprised of both cognitive and technical elements (Nonaka 1994). The cognitive element refers to an individual's mental models consisting of mental maps, beliefs, paradigms, and viewpoints. The technical component consists of concrete know-how, crafts, and skills that apply to a specific context. An example of tacit knowledge is knowledge of the best means of approaching a particular customer—using flattery, using a hard sell, using a no-nonsense approach. The explicit dimension of knowledge (henceforth referred to as explicit knowledge) is articulated, codified, and communicated in symbolic form and/or natural language. An example is an owner's manual accompanying the purchase of an electronic product. The manual contains knowledge on the appropriate operation of the product.

Table 1. Knowledge Perspectives and Their Implications		Implications for Knowledge Management (KM)	Implications for Knowledge Management Systems (KMS)
Perspectives			
Knowledge vis-à-vis data and information	Data is facts, raw numbers. Information is processed/ interpreted data. Knowledge is personalized information.	KM focuses on exposing individuals to potentially useful information and facilitating assimilation of information	KMS will not appear radically different from existing IS, but will be extended toward helping in user assimilation of information
State of mind	Knowledge is the state of knowing and understanding.	KM involves enhancing individual's learning and understanding through provision of information	Role of IT is to provide access to sources of knowledge rather than knowledge itself
Object	Knowledge is an object to be stored and manipulated.	Key KM issue is building and managing knowledge stocks	Role of IT involves gathering, storing, and transferring knowledge
Process	Knowledge is a process of applying expertise.	KM focus is on knowledge flows and the process of creation, sharing, and distributing knowledge	Role of IT is to provide link among sources of knowledge to create wider breadth and depth of knowledge flows
Access to information	Knowledge is a condition of access to information.	KM focus is organized access to and retrieval of content	Role of IT is to provide effective search and retrieval mechanisms for locating relevant information
Capability	Knowledge is the potential to influence action.	KM is about building core competencies and understanding strategic know-how	Role of IT is to enhance intellectual capital by supporting development of individual and organizational competencies

Knowledge can also be viewed as existing in the individual or the collective (Nonaka 1994). Individual knowledge is created by and exists in the individual whereas social knowledge is created by and inherent in the collective actions of a group. Both Nonaka and others (e.g., Spender 1992, 1996a, 1995b) rely heavily on the tacit-explicit, individual-collective knowledge distinction but do not provide a comprehensive explanation as to the interrelationships among the various knowledge-types. One potentially problematic aspect in the interpretation of this classification is the assumption that tacit knowledge is more valuable than explicit knowledge; this is tantamount to equating an inability to articulate knowledge with its worth. Few, with the exception of Bohn (1994), venture to suggest that explicit knowledge is more valuable than tacit knowledge, a viewpoint that if accepted might favor a technology enabled knowledge management process (technology being used to aid in explicating, storing, and disseminating knowledge).

Whether tacit or explicit knowledge is the more valuable may indeed miss the point. The two are not dichotomous states of knowledge, but mutually dependent and reinforcing qualities of knowledge: tacit knowledge forms the background necessary for assigning the structure to develop and interpret explicit knowledge (Polyani 1975). The inextricable linkage of tacit and explicit knowledge suggests that only individuals with a requisite level of shared knowledge can truly exchange knowledge: if tacit knowledge is necessary to the understanding of explicit knowledge, then in order for Individual B to understand Individual A's knowledge, there must be some overlap in their underlying knowledge bases (a shared knowledge space) (Ivari and Linger 1999; Tuomi 1999). However, it is precisely in applying technology to increase "weak ties" (i.e., informal and casual contacts among individuals) in organizations (Pickering and King 1995), and thereby increase the breadth of knowledge sharing, that IT holds promise. Yet, absent a shared knowledge space, the real impact of IT on knowledge exchange is questionable. This is a paradox that IT researchers have somewhat eschewed, and that organizational researchers have used to question the application of IT to knowledge management. To add to the paradox, the very essence of the knowledge management challenge is to amalgamate knowledge across groups for which IT can play a major role. What is most at issue is the amount of contextual information necessary for one person or group's knowledge to be readily understood by another.

It may be argued that the greater the shared knowledge space, the less the context needed for individuals to share knowledge within the group and, hence, the higher the value of explicit knowledge and the greater the value of IT applied to knowledge management. On the other hand, the smaller the existing shared knowledge space in a group, the greater the need for contextual information, the less relevant will be explicit knowledge, and hence the less applicable will be IT to knowledge management.

Tacit knowledge has received greater interest and attention than has explicit knowledge, and yet the former is not alone in providing both benefits and challenges to organizations. Explicit knowledge may pose a particular challenge related to an assumption of legitimacy by virtue of being recorded (Jordan and Jones 1997). This could lead to decision makers favoring explicit knowledge, at the expense of contradictory tacit knowledge, because it may be viewed as more legitimized and, hence, justifiable. Moreover, given the ephemeral nature of some knowledge, explicating knowledge may result in a rigidity and inflexibility, which would impede, rather than improve, performance.

The tacit-explicit knowledge classification is widely cited, although sundry other knowledge classifications exist that eschew the recondite subtleties of the tacit-explicit dimension. Some refer to knowledge as declarative (know-about or knowledge by acquaintance [Nolan Norton 1998]), procedural (know-how), causal (know-why), conditional (know-when), and relational (know-with) (Zack 1998c). A pragmatic approach to classifying knowledge simply attempts to identify types of knowledge that are useful to organizations. Examples include knowledge about customers, products, processes, and competitors, which can include best practices, know-how and heuristic rules, patterns, software code, business processes, and models; architectures, technology, and business frameworks; project experiences (proposals, work plans, and reports); and tools used to implement a process such as checklists and surveys (KPMG 1998b).

An understanding of the concept of knowledge and knowledge taxonomies is important because theoretical developments in the knowledge management area are influenced by the distinction among the different types of knowledge. Furthermore, the knowledge taxonomies discussed here can inform the design of knowledge management systems by calling attention to the need for support of different types of knowledge and the flows among these different types. Knowledge management may provide an opportunity for extending the scope of IT-based knowledge provision to include the different knowledge types summarized in Table 2.

Table 2. Knowledge Taxonomies and Examples		
Knowledge Types	**Definitions**	**Examples**
Tacit	Knowledge is rooted in actions, experience, and involvement in specific context	Best means of dealing with specific customer
Cognitive tacit:	Mental models	Individual's belief on cause-effect relationships
Technical tacit:	Know-how applicable to specific work	Surgery skills
Explicit	Articulated, generalized knowledge	Knowledge of major customers in a region
Individual	Created by and inherent in the individual	Insights gained from completed project
Social	Created by and inherent in collective actions of a group	Norms for inter-group communication
Declarative	Know-about	What drug is appropriate for an illness
Procedural	Know-how	How to administer a particular drug
Causal	Know-why	Understanding why the drug works
Conditional	Know-when	Understanding when to prescribe the drug
Relational	Know-with	Understanding how the drug interacts with other drugs
Pragmatic	Useful knowledge for an organization	Best practices, business frameworks, project experiences, engineering drawings, market reports

Knowledge Management in Organizations

The recent interest in organizational knowledge has prompted the issue of managing the knowledge to the organization's benefit. Knowledge management refers to identifying and leveraging the collective knowledge in an organization to help the organization compete (von Krogh 1998). Knowledge management is purported to increase innovativeness and responsiveness (Hackbarth 1998). A recent survey of European firms by KPMG Peat Marwick (1998b) found that almost half of the companies reported having suffered a significant setback from losing key staff with 43% experiencing impaired client or supplier relations

and 13% facing a loss of income because of the departure of a single employee. In another survey, the majority of organizations believed that much of the knowledge they needed existed inside the organization, but that identifying that it existed, finding it, and leveraging it remained problematic (Cranfield University 1998). Such problems maintaining, locating, and applying knowledge have led to systematic attempts to manage knowledge.

According to Davenport and Prusak (1998), most knowledge management projects have one of three aims: (1) to make knowledge visible and show the role of knowledge in an organization, mainly through maps, yellow pages, and hypertext

tools; (2) to develop a knowledge-intensive culture by encouraging and aggregating behaviors such as knowledge sharing (as opposed to hoarding) and proactively seeking and offering knowledge; (3) to build a knowledge infrastructure—not only a technical system, but a web of connections among people given space, time, tools, and encouragement to interact and collaborate.

Knowledge management is largely regarded as a process involving various activities. Slight discrepancies in the delineation of the processes appear in the literature, namely in terms of the number and labeling of processes rather than the underlying concepts. At a minimum, one considers the four basic processes of creating, storing/retrieving, transferring, and applying knowledge. These major processes can be subdivided, for example, into creating internal knowledge, acquiring external knowledge, storing knowledge in documents versus storing in routines (Teece 1998) as well as updating the knowledge and sharing knowledge internally and externally. We will return to the knowledge management processes in the framework section and consider the role of IT within each process.

Knowledge Management Systems

Knowledge management systems (KMS) refer to a class of information systems applied to managing organizational knowledge. That is, they are IT-based systems developed to support and enhance the organizational processes of knowledge creation, storage/retrieval, transfer, and application. While not all KM initiatives involve an implementation of IT, and admonitions against an emphasis on IT at the expense of the social and cultural facets of KM are not uncommon (Davenport and Prusak 1998; Malhotra 1999; O'Dell and Grayson 1998), many KM initiatives rely on IT as an important enabler. While IT does not apply to all of the issues of knowledge management, it can support KM in sundry ways. Examples include finding an expert or a recorded source of knowledge using online directories and searching databases; sharing knowledge and working together in virtual teams; access to information on past projects; and learning about customer needs

and behavior by analyzing transaction data (KPMG 1998a), among others. Indeed, there is no single role of IT in knowledge management just as there is no single technology comprising KMS.

Reviewing the literature discussing applications of IT to organizational knowledge management initiatives reveals three common applications: (1) the coding and sharing of best practices, (2) the creation of corporate knowledge directories, and (3) the creation of knowledge networks. One of the most common applications is internal benchmarking with the aim of transferring internal best practices (KPMG 1998a; O'Dell and Grayson 1998). For example, an insurance company was faced with the commoditization of its market and declining profits. The company found that applying the best decision making expertise via a new underwriting process supported by a knowledge management system enabled it to move into profitable niche markets and, hence, to increase income (Davenport and Prusak 1998).

Another common application of knowledge management is the creation of corporate directories, also referred to as the mapping of internal expertise. Because much knowledge in an organization remains uncodified, mapping the internal expertise is a potentially useful application of knowledge management (Ruggles 1998). One survey found that 74% of respondents believed that their organization's best knowledge was inaccessible and 68% thought that mistakes were reproduced several times (Gazeau 1998). Such perception of the failure to apply existing knowledge is an incentive for mapping internal expertise.

A third common application of knowledge management systems is the creation of knowledge networks (Ruggles 1998). For example, when Chrysler reorganized from functional to platform-based organizational units, they realized quickly that unless the suspension specialists could communicate easily with each other across platform types, expertise would deteriorate. Chrysler formed Tech Cul, bringing people together virtually and face-to-face to exchange and build their collective knowledge in each of the specialty areas. In this case, the knowledge management

effort was less focused on mapping expertise or benchmarking than it was on bringing the experts together so that important knowledge was shared and amplified. Providing online forums for communication and discussion may form knowledge networks. Buckman Laboratories uses an online interactive forum where user comments are threaded in conversational sequence and indexed by topic, author, and date. This has reportedly enabled Buckman to respond to the changing basis of competition that has evolved from merely selling products to solving customers' chemical treatment problems (Zack 1998a). In another case, Ford found that just by sharing knowledge, the development time for cars was reduced from 36 to 24 months, and through knowledge sharing with dealers, the delivery delay reduced from 50 to 15 days (Gazeau 1998).

Summary: Knowledge and the Firm

Information systems designed to support and augment organizational knowledge management need to complement and enhance the knowledge management activities of individuals and the collectivity. To achieve this, the design of information systems should be rooted in and guided by an understanding of the nature and types of organizational knowledge. Different perspectives on knowledge and various knowledge taxonomies were discussed earlier. These discussions highlight the importance of assessing and understanding an organization's knowledge position and its existing intellectual resources. Such an understanding is needed for formulating a knowledge management strategy and in analyzing the role of information technology in facilitating knowledge management (discussed in the next section). In the information systems (IS) field, it has been common to design systems primarily focused on the codified knowledge (that is, explicit organizational knowledge). Management reporting systems, decision support systems, and executive support systems have all focused on the collection and dissemination of this knowledge type. Knowledge management systems may provide an opportunity for extending the scope of IT-based knowledge provision to include the different knowledge forms and types shown in Table 2. We

are not suggesting that IT applied to the KM efforts of a given organization must provide the means of capturing all types of knowledge mentioned; the specific types of knowledge forming the substance of an IT will depend upon an organization's context. We are suggesting, however, that IT as applied to KM need not be constrained to certain types of knowledge, because the advances in communication and information technologies enable greater possibilities than existed with previous classes of information systems.

While the preponderance of knowledge management theory stems from strategy and organizational theory research, the majority of knowledge management initiatives involve at least in part, if not to a significant degree, information technology. Yet little IT research exists on the design, use, or success of systems to support knowledge management. The next section will examine the four basic knowledge management processes and the role that IT may play in each process.

Organizational Knowledge Management Processes: A Framework for Analysis of the Role of an Information System ■■■■■

In this section, we develop a systematic framework that will be used to further analyze and discuss the potential role of information technologies in organizational knowledge management. This framework is grounded in the sociology of knowledge (Berger and Luckman 1967; Gurvitch 1971; Holzner and Marx 1979) and is based on the view of organizations as social collectives and "knowledge systems." According to this framework, organizations as knowledge systems consist of four sets of socially enacted "knowledge processes": (1) creation (also referred to as construction), (2) storage/retrieval, (3) transfer, and (4) application (Holzner and Marx 1979; Pentland 1995). This view of organizations as knowledge systems represents both the cognitive and social nature of organizational knowledge and

its embodiment in the individual's cognition and practices as well as the collective (i.e., organizational) practices and culture. These processes do not represent a monolithic set of activities, but an interconnected and intertwined set of activities, as explained later in this section.

Knowledge Creation

Organizational knowledge creation involves developing new content or replacing existing content within the organization's tacit and explicit knowledge (Pentland 1995). Through social and collaborative processes as well as an individual's cognitive processes (e.g., reflection), knowledge is created, shared, amplified, enlarged, and justified in organizational settings (Nonaka 1994). This model views organizational knowledge creation as involving a continual interplay between the tacit and explicit dimensions of knowledge and a growing spiral flow as knowledge moves through individual, group, and organizational levels. Four modes of knowledge creation have been identified: socialization, externalization, internalization, and combination (Nonaka 1994). The socialization mode refers to conversion of tacit knowledge to new tacit knowledge through social interactions and shared experience among organizational members (e.g., apprenticeship). The combination mode refers to the creation of new explicit knowledge by merging, categorizing, reclassifying, and synthesizing existing explicit knowledge (e.g., literature survey reports). The other two modes involve interactions and conversion between tacit and explicit knowledge. Externalization refers to converting tacit knowledge to new explicit knowledge (e.g., articulation of best practices or lessons learned). Internalization refers to creation of new tacit knowledge from explicit knowledge (e.g., the learning and understanding that results from reading or discussion).

The four knowledge creation modes are not pure, but highly interdependent and intertwined. That is, each mode relies on, contributes to, and benefits from other modes. For example, the socialization mode can result in creation of new knowledge when an individual obtains a new insight triggered by interaction with another. On the other hand, the socialization mode may involve transferring existing tacit knowledge from one member to another through discussion of ideas. New organizational knowledge per se may not be created, but only knowledge that is new to the recipient. The combination mode in most cases involves an intermediate step—that of an individual drawing insight from explicit sources (i.e., internalization) and then coding the new knowledge into an explicit form (externalization). Finally, internalization may consist of the simple conversion of existing explicit knowledge to an individual's tacit knowledge as well as creation of new organizational knowledge when the explicit source triggers a new insight.

Figure 1 illustrates the interplay among Nonaka's knowledge creation modes, and hence may be useful in interpreting relationships between the four modes.

In Figure 1, each arrow represents a form of knowledge creation. The arrows labeled A represent externalization; the arrows labeled B represent internalization; the arrows labeled C represent socialization; and the arrows labeled D represent combination.

It may be useful to consider the conditions and environments that facilitate new knowledge creation. Nonaka and Konno (1998) suggest that the essential question of knowledge creation is establishing an organization's "ba" (defined as a common place or space for creating knowledge). Four types of ba corresponding to the four modes of knowledge creation discussed above are identified: (1) originating ba, (2) interacting ba, (3) cyber ba, and (4) exercising ba (Nonaka and Konno 1998). Originating ba entails the socialization mode of knowledge creation and is the ba from which the organizational knowledge creation process begins. Originating ba is a common place in which individuals share experiences primarily through face-to-face interactions and by being at the same place at the same time. Interacting ba is associated with the externalization mode of knowledge creation and refers to a space where tacit knowledge is converted to explicit knowledge and shared among individuals through the process of dialogue and collaboration. Cyber ba refers to a virtual space of interaction and corres-
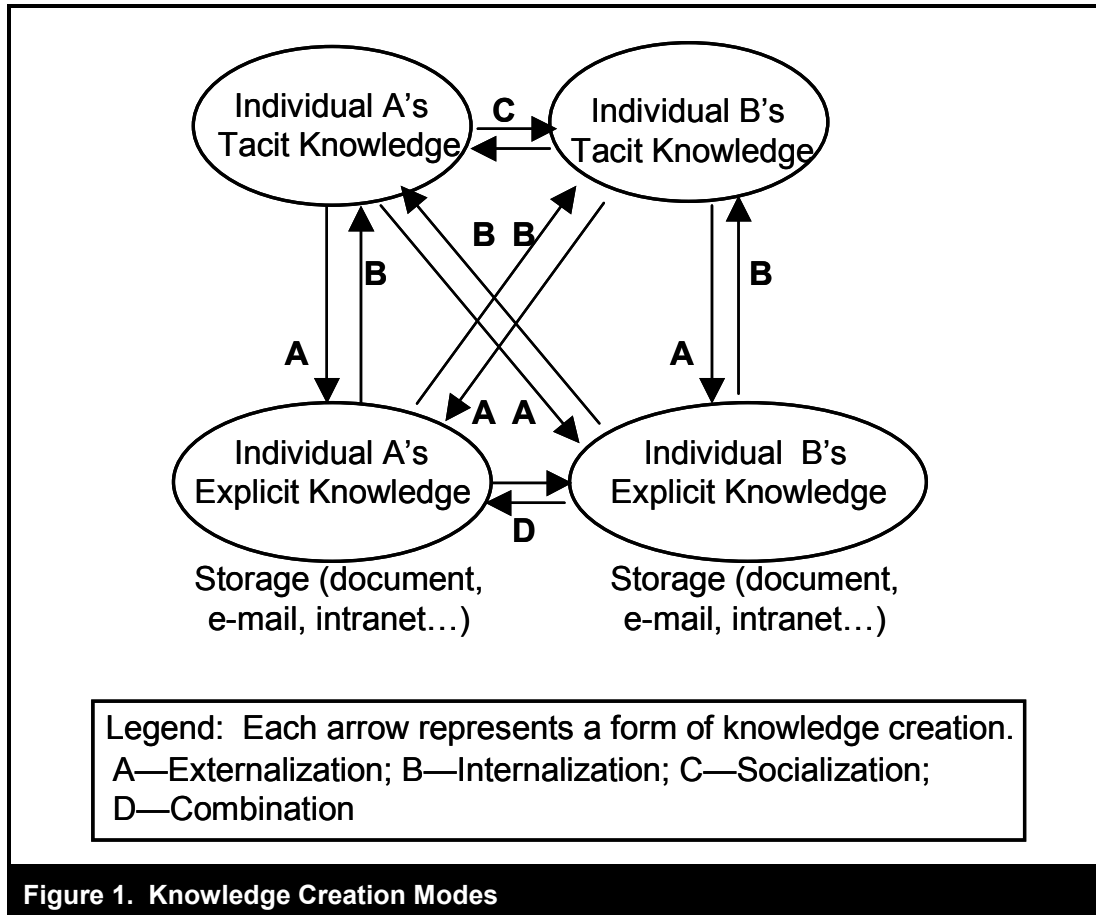
Figure 1. Knowledge Creation Modes

ponds to the combination mode of knowledge creation. Finally, exercising ba involves the conversion of explicit to tacit knowledge through the internalization process. Thus, exercising ba entails a space for active and continuous individual learning. Understanding the characteristics of various ba and the relationship with the modes of knowledge creation is important to enhancing organizational knowledge creation. For example, the use of IT capabilities in cyber ba is advocated to enhance the efficiency of the combination mode of knowledge creation (Nonaka and Konno 1998). Data warehousing and data mining, documents repositories, and software agents, for example, may be of great value in cyber ba.

We further suggest that considering the flexibility of modern IT, other forms of organizational ba and the corresponding modes of knowledge creation

can be enhanced through the use of various forms of information systems. For example, information systems designed for support of collaboration, coordination, and communication processes, as a component of the interacting ba, can facilitate teamwork and thereby increase an individual's contact with other individuals. Electronic mail and group support systems have been shown to increase the number of weak ties in organizations. This in turn can accelerate the growth of knowledge creation (Nonaka 1994). Intranets enable exposure to greater amounts of on-line organizational information, both horizontally and vertically, than may previously have been the case. As the level of information exposure increases, the internalization mode of knowledge creation, wherein individuals make observations and interpretations of information that result in new individual tacit knowledge, may increase. In this role, an intranet

can support individual learning (conversion of explicit knowledge to personal tacit knowledge) through provision of capabilities such as computer simulation (to support learning-by-doing) and smart software tutors.

Computer-mediated communication may increase the quality of knowledge creation by enabling a forum for constructing and sharing beliefs, for confirming consensual interpretation, and for allowing expression of new ideas (Henderson and Sussman 1997). By providing an extended field for interaction among organizational members for sharing ideas and perspectives, and for establishing dialog, information systems may enable individuals to arrive at new insights and/or more accurate interpretations than if left to decipher information on their own. Boland et al. (1994) provide a specific example of an information system called Spider that provides an environment for representing, exchanging, and debating different individual perspectives. The system actualizes an extended field in which "assumptions are surfaced and questioned, new constructs emerge and dialog among different perspectives is supported" (Boland et al. 1994, pp. 467). As such, the quality and frequency of the knowledge creation is improved.

Knowledge Storage/Retrieval

Empirical studies have shown that while organizations create knowledge and learn, they also forget (i.e., do not remember or lose track of the acquired knowledge) (Argote et al. 1990; Darr et al. 1995). Thus, the storage, organization, and retrieval of organizational knowledge, also referred to as organizational memory (Stein and Zwass 1995; Walsh and Ungson 1991), constitute an important aspect of effective organizational knowledge management. Organizational memory includes knowledge residing in various component forms, including written documentation, structured information stored in electronic databases, codified human knowledge stored in expert systems, documented organizational procedures and processes and tacit knowledge acquired by individuals and networks of individuals (Tan et al. 1999).

Similar to the knowledge creation process described in the previous section, a distinction between individual and organizational memory has been made in the literature. Individual memory is developed based on a person's observations, experiences, and actions (Argyris and Schön 1978; Nystrom and Starbuck 1981; Sanderlands and Stablein 1987). Collective or organizational memory is defined as "the means by which knowledge from the past, experience, and events influence present organizational activities" (Stein and Zwass 1995, p. 85). Organizational memory extends beyond the individual's memory to include other components such as organizational culture, transformations (production processes and work procedures), structure (formal organizational roles), ecology (physical work setting) and information archives (both internal and external to the organization) (Walsh and Ungson 1991).

Organizational memory is classified as semantic or episodic (El Sawy et al. 1996; Stein and Zwass 1995). Semantic memory refers to general, explicit and articulated knowledge (e.g., organizational archives of annual reports), whereas episodic memory refers to context-specific and situated knowledge (e.g., specific circumstances of organizational decisions and their outcomes, place, and time). Memory may have both positive and negative potential influences on behavior and performance. On the positive side, basing and relating organizational change in past experience facilitates implementation of the change (Wilkins and Bristow 1987). Memory also helps in storing and reapplying workable solutions in the form of standards and procedures, which in turn avoid the waste of organizational resources in replicating previous work.

On the other hand, memory has a potential negative influence on individual and organizational performance. At the individual level, memory can result in decision-making bias (Starbuck and Hedberg 1977). At the organizational level, memory may lead to maintaining the status quo by reinforcing single loop learning (defined as a process of detecting and correcting errors) (Argyris and Schön 1978). This could in turn lead to stable, consistent organizational cultures that are resistant to change (Denison and Mishra 1995).

Despite the concerns about the potential constraining role of organizational memory, there is a positive perspective on the influence of IT-enabled organizational memory on the behavior and performance of individuals and organizations.

Advanced computer storage technology and sophisticated retrieval techniques, such as query languages, multimedia databases, and database management systems, can be effective tools in enhancing organizational memory. These tools increase the speed at which organizational memory can be accessed. Weiser and Morrison (1998) give the example of AI-STARS, a project memory system at DEC (Digital Equipment Corporation) that combines such information as bulletin board postings, product release statements, service manuals, and e-mail messages to enable rapid access to product information for assisting customer problems. Product memory can be facilitated with corporate intranets, so that product and pricing changes can be immediately noted in the system instead of having brochures reprinted. This in turn avoids the lag time resulting from the time a change occurs to the time when the sales personnel become aware of the change (Leidner 1998).

Groupware enables organizations to create intra-organizational memory in the form of both structured and unstructured information and to share this memory across time and space (Vandenbosch and Ginzberg 1996). For example, McKinnsey's Practice Development Network places core project documentation online for the purposes of promoting memory and learning organization-wide (Stein and Zwass 1995). IT can play an important role in the enhancement and expansion of both semantic and episodic organizational memory. Document management technology allows knowledge of an organization's past, often dispersed among a variety of retention facilities, to be effectively stored and made accessible (Stein and Zwass 1995). Drawing on these technologies, most consulting firms have created semantic memories by developing vast repositories of knowledge about customers, projects, competition, and the industries they serve (Alavi 1997).
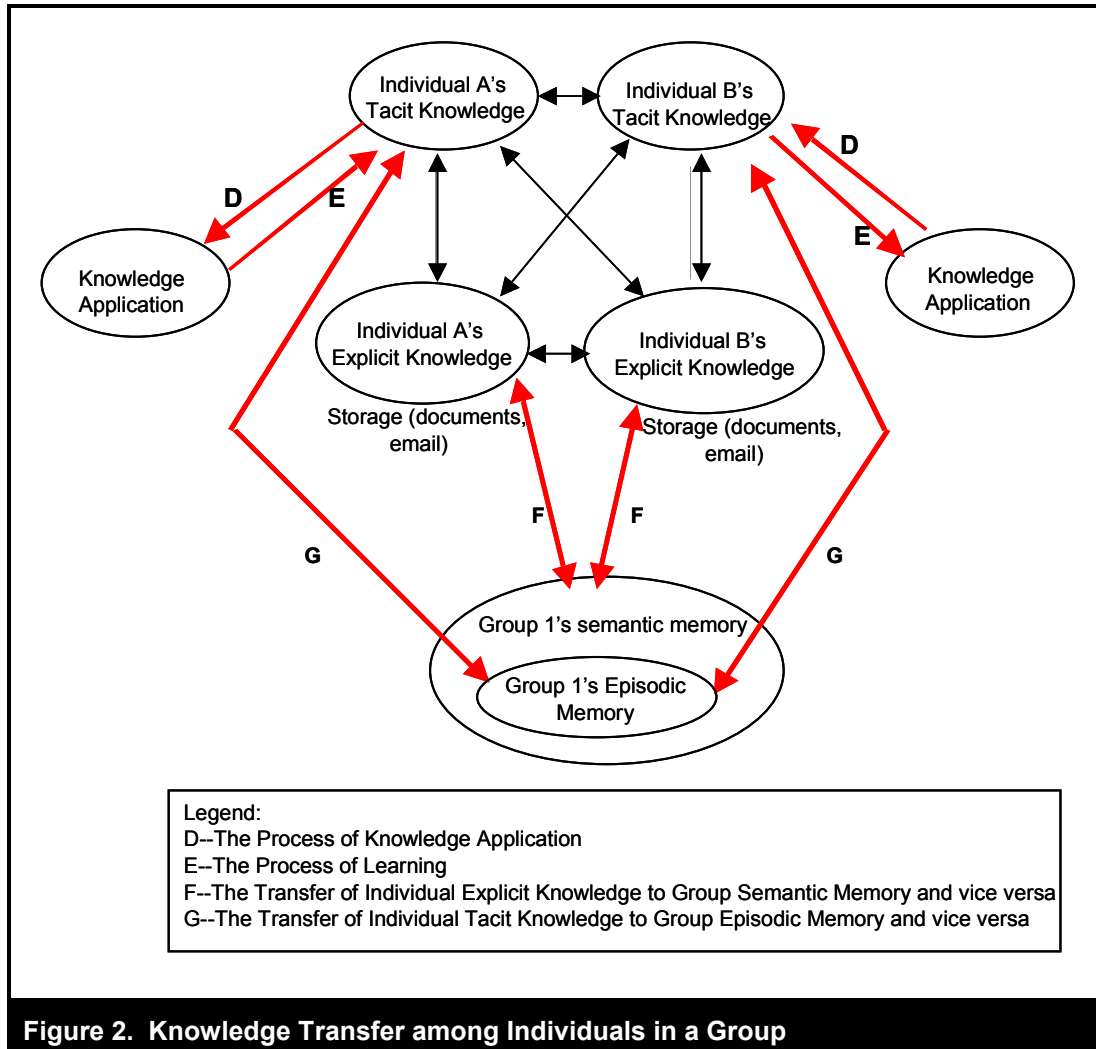
Knowledge Transfer

Having discussed knowledge creation and storage/retrieval, we now expand Figure 1 into Figure 2 and consider the important issue of knowledge transfer. The arrows from Figure 1 are now represented as two-way arrows.

In Figure 2, the arrows labeled D represent the process of knowledge application and those labeled E represent the learning, or new knowledge creation, that occurs when individuals apply knowledge and observe the results. The arrows labeled F represent the transfer of an individual's explicit knowledge to group semantic memory (which can occur, for instance, when individuals place reports they have prepared on a group server for others to view). The arrows labeled G represent the possible transfer from individual tacit knowledge to group episodic memory. Individuals may likewise learn from the group semantic and episodic memories, reflected in arrows F and G. Indeed, the group episodic memory is critical in helping an individual interpret and learn from the group semantic memory.

As the figure illustrates, an important process in knowledge management is that of knowledge transfer, with each transfer of knowledge represented by an arrow. Transfer occurs at various levels: transfer of knowledge between individuals, from individuals to explicit sources, from individuals to groups, between groups, across groups, and from the group to the organization.

Considering the distributed nature of organizational cognition, an important process of knowledge management in organizational settings is the transfer of knowledge to locations where it is needed and can be used. However, this is not a simple process in that organizations often do not know what they know and have weak systems for locating and retrieving knowledge that resides in them (Huber 1991). Communication processes and information flows drive knowledge transfer in organizations. Gupta and Govindarajan (2000) have conceptualized knowledge transfer (knowledge flows in their terminology) in terms of five

Figure 2. Knowledge Transfer among Individuals in a Group

elements: (1) perceived value of the source unit's knowledge, (2) motivational disposition of the source (i.e., their willingness to share knowledge), (3) existence and richness of transmission channels, (4) motivational disposition of the receiving unit (i.e., their willingness to acquire knowledge from the source), and (5) the absorptive capacity of the receiving unit, defined as the ability not only to acquire and assimilate but also to use knowledge (Cohen and Levinthal 1990). The least controllable element is the fifth: knowledge must go through a recreation process in the mind of the receiver (El Sawy et al. 1998). This recreation depends on the recipient's cognitive capacity to process the incoming stimuli (Vance and Eynon 1998).

The majority of the literature focuses on the third element, that of the knowledge transfer channels. Knowledge transfer channels can be informal or formal, personal or impersonal (Holtham and Courtney 1998). Informal mechanisms, such as unscheduled meetings, informal seminars, or coffee break conversations, may be effective in promoting socialization but may preclude wide dissemination (Holtham and Courtney 1998). Such mechanisms may also be more effective in small organizations (Fahey and Prusak 1998). However, such mechanisms may involve certain amounts of knowledge atrophy in that, absent a formal coding of the knowledge, there is no guarantee that the knowledge will be passed

accurately from one member to others. This parallels problems with the recipient's ability to process the knowledge. Learning problems can involve recipients filtering the knowledge they exchange, interpreting the knowledge from their own frame of reference, or learning from only a select group of knowledge holders (Huysam et al. 1998). Formal transfer mechanisms, such as training sessions and plant tours, may ensure greater distribution of knowledge but may inhibit creativity. Personal channels, such as apprenticeships or personnel transfers, may be more effective for distributing highly context specific knowledge whereas impersonal channels, such as knowledge repositories, may be most effective for knowledge that can be readily generalized to other contexts. Personnel transfer is a formal, personal mechanism of knowledge transfer. Such transfers, common in Japan, immerse team members in the routines of other members, thereby allowing access to the partner's stock of tacit knowledge (Fahey and Prusak 1998). A benefit is that learning takes place without the need to first convert tacit knowledge to explicit, saving time and resources and preserving the original knowledge base (Fahey and Prusak 1998). The most effective transfer mechanism depends upon the type of knowledge being transferred (Inkpen and Dinur 1998). Much as the existence of "care" may be important to knowledge transfer between individuals, the existence of a close, tight interface is critical at the organizational level. A narrow and distant interface has been found to be an obstacle to learning and knowledge sharing (Inkpen and Dikur 1998).

IT can support all four forms of knowledge transfer, but has mostly been applied to informal, impersonal means (through such venues as Lotus Notes discussion databases) and formal, impersonal means (such as knowledge maps or corporate directories). An innovative use of technology for transfer is the use of intelligent agent software to develop interest profiles of organizational members in order to determine which members might be interested recipients of point-to-point electronic messages exchanged among other members (O'Dell and Grayson 1998). Employing video

technologies can also enhance transfer. For example, offshore drilling knowledge is made available globally at British Petroleum by desktop video conferencing in which a screen will include images of the participants, windows of technical data, video clips of the physical issue under consideration, specifications, contractual data, and plans (Cranfield University 1998).

IT can increase knowledge transfer by extending the individual's reach beyond the formal communication lines. The search for knowledge sources is usually limited to immediate coworkers in regular and routine contact with the individual. However, individuals are unlikely to encounter new knowledge through their close-knit work networks because individuals in the same clique tend to possess similar information (Robertson et al. 1996). Moreover, studies show that individuals are decidedly unaware of what their cohorts are doing (Kogut and Zander 1996). Thus, expanding the individual's network to more extended, although perhaps weaker, connections is central to the knowledge diffusion process because such networks expose individuals to more new ideas (Robertson et al. 1996). Computer networks and electronic bulletin boards and discussion groups create a forum that facilitates contact between the person seeking knowledge and those who may have access to the knowledge. For example, this may be accomplished by posting a question in the form of "does anybody know" or a "request for help" to the discussion group. Corporate directories may enable individuals to rapidly locate the individual who has the knowledge that might help them solve a current problem. At Hewlett-Packard, the primary content of one system is a set of expert profiles containing a directory of the backgrounds, skills, and expertise of individuals who are knowledgeable on various topics. Often such metadata (knowledge about where the knowledge resides) proves to be as important as the original knowledge itself (Andreu and Ciborra 1997). Providing taxonomies or organizational knowledge maps enables individuals to rapidly locate either the knowledge or the individual who has the needed knowledge, more rapidly than would be possible without such IT-based support (Offsey 1997).

Knowledge Application

An important aspect of the knowledge-based theory of the firm is that the source of competitive advantage resides in the application of the knowledge rather than in the knowledge itself. Grant (1996b) identifies three primary mechanisms for the integration of knowledge to create organizational capability: directives, organizational routines, and self-contained task teams. Directives refer to the specific set of rules, standards, procedures, and instructions developed through the conversion of specialists' tacit knowledge to explicit and integrated knowledge for efficient communication to non-specialists (Demsetz 1991). Examples include directives for hazardous waste disposal or airplane safety checks and maintenance. Organizational routines refer to the development of task performance and coordination patterns, interaction protocols, and process specifications that allow individuals to apply and integrate their specialized knowledge without the need to articulate and communicate what they know to others. Routines may be relatively simple (e.g., organizing activities based on time-patterned sequences such as an assembly line), or highly complex (e.g., a cockpit crew flying a large passenger airplane). The third knowledge integration mechanism is the creation of self-contained task teams. In situations in which task uncertainty and complexity prevent the specification of directives and organizational routines, teams of individuals with prerequisite knowledge and specialty are formed for problem solving.

Technology can support knowledge application by embedding knowledge into organizational routines. Procedures that are culture-bound can be embedded into IT so that the systems themselves become examples of organizational norms. An example is Mrs. Field's use of systems designed to assist in every decision from hiring personnel to when to put free samples of cookies out on the table. The system transmits the norms and beliefs held by the head of the company to organizational members (Bloodgood and Salisbury 1998). Technology enforced knowledge application raises a concern that knowledge will continue to be applied after its real usefulness has declined. While the institutionalization of "best practices" by em-

bedding them into IT might facilitate efficient handling of routine, "linear," and predictable situations during stable or incrementally changing environments, when change is radical and discontinuous, there is a persistent need for continual renewal of the basic premises underlying the practices archived in the knowledge repositories (Malhotra 1999). This underscores the need for organizational members to remain attuned to contextual factors and explicitly consider the specific circumstances of the current environment. A second problem may be deciding upon the rules and routines to apply to a problem, given that over time, the organization has learned and codified a large number of rules and routines, so that choosing which rules to activate for a specific choice making scenario is itself problematic. Shared meanings and understandings about the nature and needs of a particular situation can be used to guide rule activation (Nolan Norton 1998).

Although there are challenges with applying existing knowledge, IT can have a positive influence on knowledge application. IT can enhance knowledge integration and application by facilitating the capture, updating, and accessibility of organizational directives. For example, many organizations are enhancing the ease of access and maintenance of their directives (repair manuals, policies, and standards) by making them available on corporate intranets. This increases the speed at which changes can be applied. Also, organizational units can follow a faster learning curve by accessing the knowledge of other units having gone through similar experiences. Moreover, by increasing the size of individuals' internal social networks and by increasing the amount of organizational memory available, information technologies allow for organizational knowledge to be applied across time and space. IT can also enhance the speed of knowledge integration and application by codifying and automating organizational routines. Workflow automation systems are examples of IT applications that reduce the need for communication and coordination and enable more efficient use of organizational routines through timely and automatic routing of work-related documents, information, rules, and activities. Rule based expert systems are another means of capturing and enforcing well specified organizational procedures.
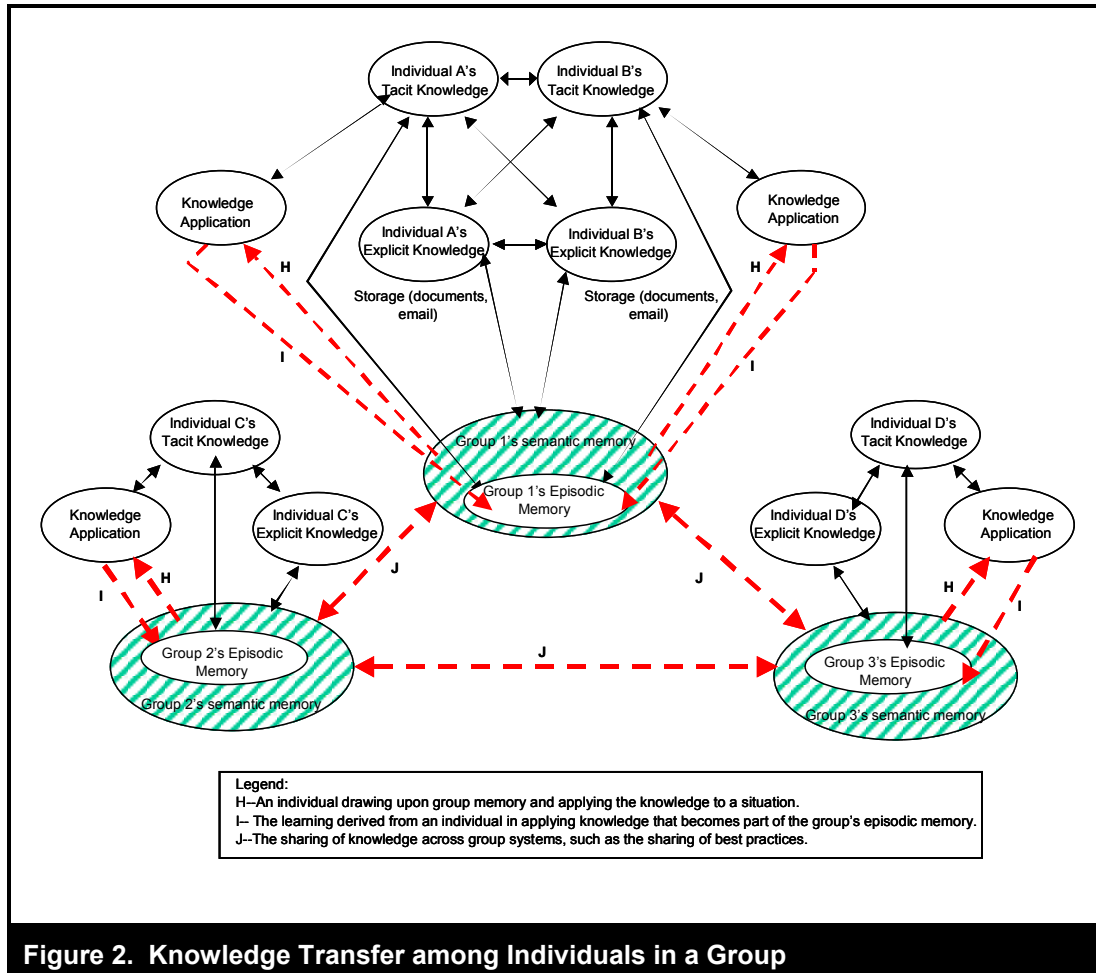
Figure 2. Knowledge Transfer among Individuals in a Group

Summary: Organizational Knowledge Management Processes

To summarize, this section has described and elaborated on a knowledge management framework based on the view of organizations as knowledge systems. One of the important implications of this framework is that knowledge management consists of a dynamic and continuous set of processes and practices embedded in individuals, as well as in groups and physical structures. At any point in time and in any part of a given organization, individuals and groups may be engaged in several different aspects and processes of knowledge management. Thus, knowledge management is not a discrete, independent, and monolithic organizational pheno-

menon. Figure 3 builds upon Figure 2 to illustrate the "web" of knowledge management activities in organizational settings. The figure introduces two new groups—Groups 2 and 3—to illustrate the potential knowledge transfer across groups. For simplicity purposes, only one member is represented in Groups 2 and 3.

Figure 3 depicts the transfer of knowledge among individuals and groups. Once individual A shares (transfers) some knowledge with individual B, individual B's knowledge processes may have been triggered. For example, A's knowledge transfer may lead to B's knowledge creation. B may chose to apply the knowledge, consult with other members, or record the knowledge. Knowledge hence flows between individuals and

a major challenge of KM is to facilitate these flows so that the maximum amount of transfer occurs (assuming that the knowledge individuals create has value and can improve performance). Individuals in a group or community of practice then develop a group knowledge (the collectivity of their stored memory, be it organized informally in e-mail communications or formally in a knowledge repository). The individual is connected to the group processes through transfer (an individual may share knowledge with the group during a decision-making meeting, for example) or through a centralized storage mechanism (e.g., computer files or regular meetings). Individuals can then call on the centralized memory to make decisions, if needed (arrows H). Individuals learn from the application of knowledge and their learning becomes embedded into their tacit knowledge space and the group's episodic memory (arrows I). Organizational knowledge processes would then consist of the summation of the individual and group knowledge processes. In this case, one group may have acquired and applied knowledge to a given situation and coded this knowledge in the form of a certain routine. This "best practice" may then be shared with other groups by allowing access to group memory systems (arrows J) or by facilitating intergroup dialogue.

Figure 3 can elucidate some of the major challenges of knowledge management at the individual, group, and the organizational (i.e., inter-groups) levels. One primary challenge is to make individual knowledge available, and meaningful, to others (Ackerman and Halverson 1999). At the group level, this means enabling a group's episodic memory to be accessible to other groups, implying an overlap in group membership. The codification of knowledge into semantic memory neither guarantees efficient dissemination nor effective storage (Jordan and Jones 1997). Transfer among groups may be challenged not only by the lack of shared episodic memory, but by the practical issue of informing groups of when the semantic memory of a group has been modified (say, a new important document summarizing a flaw in product design is now available on the group intranet of an overseas R&D unit). Even if one group is aware of, and chooses to access,

another's semantic memory, how does the receiving group validate the information and determine whether to apply it? Group gatekeepers (internal boundary spanners) may act as links between the episodic memory of two groups and, hence, increase the relevance of knowledge transfer. Do certain individuals act as such internal boundary spanners, searching within an extended network for practices that might improve their unit? In short, to improve knowledge management, utilizing information technology implies attention not only to improving the individual and group level processes of knowledge creation and storage, but also to improving the linkages among individuals and between groups.

Another implication of this framework is that the four knowledge processes of creation, storage/retrieval, transfer, and application are essential to effective organizational knowledge management. We contend that the application of information technologies can create an infrastructure and environment that contribute to organizational knowledge management by actualizing, supporting, augmenting, and reinforcing knowledge processes at a deep level through enhancing their underlying dynamics, scope, timing, and overall synergy. Table 3 summarizes the four processes and the potential role of IT in facilitating each process. While the four processes are presented as discrete, it is important to realize that we are not implying a linear sequence, as evident in the Figures 1, 2 and 3. An individual may create new knowledge (have a new insight) and immediately apply this knowledge (use it as the basis of a decision, for example) without either storing it (except in his/her internal memory) or transferring it to others. The application of the knowledge may lead to additional new knowledge (perhaps concerning how best to apply the knowledge), which may or may not be coded or transferred. Knowledge that has been applied might be coded after application (e.g., incorporated into an organizational routine). The objective of Table 3 is not to provide an exhaustive set of IT tools for KM, but to illustrate that a variety of IT tools may be drawn upon for support of different KM processes in organizations.

Table 3. Knowledge Management Processes and the Potential Role of IT

Knowledge Management Processes	Knowledge Creation	Knowledge Storage/Retrieval	Knowledge Transfer	Knowledge Application
Supporting Information Technologies	Data mining Learning tools	Electronic bulletin boards Knowledge repositories Databases	Electronic bulletin boards Discussion forums Knowledge directories	Expert systems Workflow systems
IT Enables	Combining new sources of knowledge Just in time learning	Support of individual and organizational memory Inter-group knowledge access	More extensive internal network More communication channels available Faster access to knowledge sources	Knowledge can be applied in many locations More rapid application of new knowledge through workflow automation
Platform Technologies	Groupware and communication technologies			
	INTRANETS			

Research Issues in Knowledge Management ■■■■■■

The review of the literature on knowledge, knowledge management, and knowledge management systems uncovers a broad gamut of potential research streams. While much theory exists on knowledge management, little empirical work has been undertaken. Hence, there are large gaps in the body of knowledge in this area. In this section, we will briefly highlight some research themes that, in our view, aim at bridging the gaps.

Research Issues on Knowledge Creation

Much of the existing research on knowledge creation focuses on the source and state of knowledge. Research is now needed that moves beyond the source and state to consider the conditions that facilitate knowledge creation. Descriptive studies have identified culture as a major catalyst, or alternatively a major hindrance, to knowledge creation and sharing. A knowledge-friendly organizational culture has been identified as one of the most important conditions leading to the success of KM initiatives in organizations (Davenport and Prusak 1998). Firm-wide KMS usually require profound cultural renovations because, traditionally, organizations have rewarded their professionals and employees based on their individual performance and know-how. Cultural barriers to KM (e.g., organizational norms that promote and encourage knowledge hoarding) cannot be effectively reduced or eliminated through IT applications. In many organizations, a major cultural shift may be required to change employees' attitudes and behavior so that they willingly and consistently share their knowledge and insights. If so, must cultural change occur before knowledge management initiatives can be successfully undertaken or can knowledge management initiatives facilitate cultural change? What cultures foster knowledge creation? Research can examine the relationships between various organizational cultures and knowledge creation.

Organizational design, in particular the building of communities of practice and shared knowledge creation spaces, is also considered an important catalyst for knowledge creation. For instance, at 3M, employees can set aside 15% of their work time to pursue personal research interests. Computer terminals are located throughout the company, including large open meeting areas around which people may gather to partake in discussions. In concert with the integration of open access to knowledge databases, coordination between production, marketing, distribution, and product design is improved (Graham and Pizzo 1998). As was shown in Figure 3, individuals may benefit more from semantic memory if they also share an episodic memory. Organizational design can be used to increase the episodic memory and, hence, make the semantic memory more readily interpretable.

Some argue that the close ties in a community limit knowledge creation because individuals are unlikely to encounter new ideas in close-knit networks where they tend to possess similar information (Robertson et al. 1996). This view upholds the need for weak ties to expose individuals to new ideas that can trigger new knowledge creation. In terms of design, much can be done to encourage knowledge creation, storage/retrieval, and transfer. Distant, informal, spontaneous contact between different organizational subunits might be an important mechanism for knowledge creation (Roberston et al. 1996). The alternate view argues that knowledge creation is better served by close ties in a community of practice since individuals share a common language and would be more at ease discussing ideas openly and challenging the ideas of others. Moreover, such communities develop a shared understanding or a "collective knowledge base" (Brown and Duguid 1998) from which knowledge emerges. Hayduk (1998) hypothesizes that learning processes are more effective when shared within or among a self-selected peer group. Thus, one research question whether IT can enhance knowledge creation by enabling weak ties (e.g., spontaneous e-mail exchanges among distant members of an organization) while reinforcing close ties (by allowing more frequent interactions among the members of a community of practice). Can, and if so, how do, communities of practice evolve rapidly through electronic connections and interactions alone?

Table 4. Research Questions Concerning Knowledge Creation
Research Question 1: What conditions facilitate knowledge creation in organizations?
Research Question 1a: Do certain organizational cultures foster knowledge creation?
Research Question 1b: Can IT enhance knowledge creation by enabling weak ties to develop and by reinforcing existing close ties?
Research Question 1c: How is knowledge originating from outside a unit evaluated for internal use?
Research Question 1d: Does lack of a shared context inhibit the adoption of knowledge originating from outside a unit?

Research is also needed to determine how tight collaboration should be within the shared space to improve and accelerate knowledge creation and whether shared knowledge creation spaces can be designed in such a manner to tighten collaboration (El Sawy et al. 1998). Research could also consider how knowledge coming from outside the shared space is evaluated: does a lack of context prevent the effective adoption of outside knowledge? Or are members able to adopt and modify outside knowledge to meet their needs? Answers to these questions have implications for the appropriate scale and features of knowledge management systems. Table 4 summarizes the research questions concerning knowledge creation.

Research Issues on Knowledge Storage and Retrieval

Knowledge storage involves obtaining the knowledge from organizational members and/or external sources, coding and indexing the knowledge (for later retrieval), and capturing it. Incentives are important to overcome some of the major barriers to knowledge storage success. These barriers include the lack of employee time to contribute their knowledge (Cranfield University 1998; KPMG 1998b) and a corporate culture that has historically not rewarded contributing and sharing of insights (Brown and Duguid 1998; Cranfield University 1998; KPMG 1998b). Many organizations are relatively lean and many employees do not have time to make knowledge available, share it with others, teach and mentor others, use their expertise to innovate, or find ways of working

smarter (Glazer 1998). Instead, they are task-focused, shifting existing workloads to fight deadlines. Moreover, in many organizations, members feel that their futures with the company are dependent upon the expertise they generate and not on the extent to which they help others. In such situations, it is then expected that individuals will attempt to build up and defend their own hegemonies of knowledge (von Krogh 1998). People may be unaware of what they have learned; moreover, even if they realize what they have learned from a project, they may be unaware of what aspects of their learning would be relevant for others. Without a systematic routine for capturing knowledge, a firm might not benefit from its best knowledge being captured. Research is needed to address the issue of what types of incentives are effective in inculcating organizational members with valuable knowledge to contribute and share their knowledge.

An important consideration with storing knowledge is how much context to include. When the context surrounding knowledge creation is not shared, it is questionable whether storing the knowledge without sufficient contextual detail will result in effective uses. This could lead to the essence of the knowledge being lost (Zack 1998c). In addition to the question of how much context to capture is the question of how much knowledge to code and store. The more readily available the knowledge, the more likely its reuse. On the other hand, the more readily available, the greater the likelihood of knowledge misuse, i.e., knowledge being misapplied to a different context. Furthermore, today's knowledge may be tomorrow's ignorance in the sense that knowledge emerges

Table 5. Research Questions Concerning Knowledge Storage and Retrieval
Research Question 2: What incentives are effective in encouraging knowledge contribution and sharing in organizations?
Research Question 2a: How much context needs to be included in knowledge storing to ensure effective interpretation and application?
Research Question 2b: Is stored knowledge accessed and applied by individuals who do not know the originator of the knowledge?
Research Question 2c: What retrieval mechanisms are most effective in enabling knowledge retrieval.

and evolves over time and any system designed to store the knowledge must ensure that the knowledge is dynamic and updated rather than static.   To be useful, it should be easy to retrieve the captured knowledge. Creation of easy to use and easy to remember retrieval mechanisms (e.g., search and retrieval commands) are important aspects of an organizational KM strategy.   A variety of search and retrieval approaches and tools (e.g., browsers) to access organizational knowledge captured in data warehouses and knowledge repositories exist. Two general models to information retrieval exist, the "pull" and the "push" models. The pull model is the traditional model and involves search for and retrieval of information based on specific user queries. In the push model, information is automatically retrieved and delivered to the potential user based upon some predetermined criteria. The challenge in design of organizational knowledge retrieval strategies is providing timely and easy access to knowledge while avoiding a condition of information overload.   Thus, as summarized in Table 5, research is needed to address several important issues regarding knowledge storage and retrieval.

Research Issues on Knowledge Transfer

The notion of knowledge transfer raises several important issues: first is the question of to what degree knowledge needs to be, and even can be, transferred internally, which may depend upon the extent of interdependency among subgroups or individuals (Leonard and Sensiper 1998). Given the ease with which individuals are able to transfer the explicit components of their knowledge, we would expect them to transfer more knowledge than they would if they had to rely solely on verbal or face-to-face communication. However, this does not imply that individuals will expand the number of other people with whom they share knowledge. They may simply share more with the same individuals (such as via e-mail or groupware) by virtue of the ease and speed with which they are able to electronically transfer information to their cohorts. Thus, a primary question concerning knowledge transfer is the degree to which knowledge transfer is increased in an organization as a result of applying information technology to the knowledge management initiative.

A second major issue involves locating knowledge, both how to find needed knowledge documents and how to find the knowledge needed within a large collection of documents (Dworman 1998).   One system, Homer, sorts through collections of documents to find specific information relevant to a query as well as to identify patterns of information in a large collection of documents (Dworman 1998). A problem, similar to the information overload problem, exists when individuals are aware that the relevant knowledge exists in organizational memory, but are discouraged from searching for the knowledge by the sheer volume of available knowledge. For example, most developers at Hewlett-Packard are aware that the SPaM system holds all of their past projects history, but rarely seek answers in SPaM because finding the answer would take days (Powell 1998). Thus, research on the development of effective organizational and technical strategies for organizing, retrieving, and transmitting knowledge are needed to facilitate knowledge transfer.

Table 6. Research Questions Concerning Knowledge Transfer
Research Question 3: How can knowledge be effectively transferred among organizational units?
Research Question 3a: To what degree does the application of IT to knowledge transfer increase the transfer of knowledge among individuals within a group and between groups?
Research Question 3b: What organizational and technical strategies are effective in facilitating knowledge transfer?
Research Question 3c: What social, cultural, or technical attributes of organizational settings encourage knowledge transfer by balancing the push and pull processes?
Research Question 3d: Does the application of IT to knowledge transfer inadvertently discourage external searches for knowledge?

A third important issue on knowledge transfer concerns knowledge flows between the provider (source) and the knowledge seeker. From the provider's perspective, flow is a selective pull process; from a seeker's perspective, flow is a selective push process (Holthouse 1998). Balancing the pull and push processes then is an important aspect of knowledge transfer in organizations. Research that focuses on social, cultural, and technical attributes of organizational settings that encourage and facilitate knowledge flows by balancing the push and pull processes is important.

Finally, a consideration with knowledge transfer is the extent to which individuals discontinue external searches for new knowledge and rely solely on internal knowledge, so that knowledge is transferred internally but little external knowledge is transferred into the organization. A reliance on IT may facilitate the process of coding knowledge into semantic memory and improving internal linkages within a group and among groups, but individuals may consequently spend more time focusing on internal than external searches for knowledge. Table 6 summarizes the research questions concerning knowledge transfer.

Research Issues on Knowledge Application

The processes of knowledge creation, storage/retrieval, and transfer do not necessarily lead to enhanced organizational performance; effective knowledge application does. Organizational per-formance often depends more on an ability to turn knowledge into effective action and less on knowledge itself. It is widely recognized that organizations have gaps between what they know and what they do (Pfeffer and Sutton 2000). There may be several reasons for organizational members to access and assimilate knowledge but not apply it (i.e., act upon it). Reasons include distrusting the source of knowledge, lack of time or opportunity to apply knowledge, or risk aversion (particularly in organizations that punish mistakes) (Davenport and Prusak 1998). Thus, knowledge access and transfer are only partial steps toward knowledge application. Learning literature provides us with some important insights into the cognitive processes underlying knowledge absorption and its applications to problem solving and decision making by individuals. For example, work in the area of knowledge structures has demonstrated that in most cases the cognitive processes (problem solving and decision making) of individuals in organizational settings are enacted with little attention and through invoking preexisting knowledge and cognitive "routines" (Gioia and Pool 1984). This approach leads to reduction in cognitive load and is, therefore, an effective strategy in dealing with individual cognitive limitations. On the other hand, it creates a barrier to search, absorption, and application of new knowledge in organizations (Alavi 2000).

An important area of KM research consists of an identification of these factors and the development of organizational practices and systems to bridge the knowledge application gap. Table 7 summarizes the research questions concerning knowledge application.

Table 7. Research Questions Concerning Knowledge Application
Research Question 4: How can an organization encourage application of knowledge that is made available?
Research Question 4a: What factors contribute to the knowing-doing gap in organizations and how can they be reduced or eliminated?
Research Question 4b: What organizational practices can help bridge the knowledge application gap?

IT and the Knowledge Management Initiatives

The above four areas of research questions included questions related to the role of IT in the four knowledge management processes. There are also many broad questions related to the role and impact of IT on knowledge management initiatives, several of which are highlighted in this section.

Our analysis of the literature suggests that IT can lead to a greater breadth and depth of knowledge creation, storage, transfer, and application in organizations. While these suppositions in general can be applied to most IT designed to provide information and could form the subject of research in themselves, an interesting line of research would consider the subsequent question of whether and how having knowledge available from more vertical and horizontal sources in the organization in a more timely manner may enhance individual and organizational performance. Does an increase in the breadth and depth of knowledge result in greater use of a knowledge management system and greater use of available knowledge, or contrarily, does such an expanded availability discourage usage as the potential search and absorption time for needed knowledge might simultaneously increase? Does an increase in the breadth, depth, quality, and timeliness of organizational knowledge result in improved decision making, reduced product cycles, greater productivity, or better customer service?   In general, what are the consequences of increasing the breadth, depth, quality, and timeliness of organizational knowledge?

There is debate as to whether information technology inhibits or facilitates knowledge creation and use. On the one hand, some argue that capturing knowledge in a KMS inhibits learning (Cole 1998) and may result in the same knowledge being applied to different situations even when it might not be appropriate. Proponents of this view maintain that IT plays a limited role in knowledge creation because IT is only helpful if an individual knows what he is looking for (the search is necessary but the solution is obvious) (Powell 1998). In this case, little new knowledge creation can occur. Moreover, some argue that the mechanistic and rigid nature of IT-based KM is incapable of keeping pace with dynamic needs of knowledge creation (Malhotra 1999). However, this argument is not so much about information technology as about the role of explicit knowledge. The issue is how to ensure that individuals modify explicit knowledge to meet their situation and thereby create new knowledge. Once individuals modify and use knowledge from a KMS, do they then transfer their experiences into modified knowledge for others to use, or is existing knowledge continually reused in various ways with no record of the modifications? What level of trust do individuals have in knowledge that resides in a system but the originator of which they do not personally know? How can trust be developed to enhance the individual's use of knowledge in a KMS?

As with most information systems, the success of KMS partially depends upon the extent of use, which itself may be tied to system quality, information quality, and usefulness (Delone and McLean 1992). System quality is influenced by attributes such as ease of use, characteristics of human-computer interface, and flexibility and effectiveness of search mechanisms. Research focusing on KMS use process, and development of intuitive search, retrieval, and display, is

Table 8. Research Questions Concerning the Application of IT to Knowledge Management
Research Question 5: What are the consequences of increasing the breadth and depth of available knowledge, via information technology, on organizational performance?
Research Question 5a: How can an organization ensure that knowledge captured via information technology is effectively modified where necessary prior to application?
Research Question 5b: How can an organization ensure that IT captures modifications to knowledge along with the original knowledge?
Research Question 5c: How do individuals develop trust in knowledge captured via IT, the originator of which they may not know?
Research Question 5d: What factors are related to the quality and usefulness of information systems applied to knowledge management initiatives?

needed to enhance KMS quality. At the level of knowledge quality, issues pertain to what kinds of knowledge can be usefully codified and at what level of detail, how to protect coded knowledge from unauthorized access or copying, and how to ensure that the knowledge is maintained (KPMG 1998b). In terms of KMS usefulness, studies can examine the extent to which available knowledge is reused. Ratios of knowledge accessed to knowledge available and knowledge used to knowledge accessed could give an indication of system usefulness. Equally important to consider would be the number of searches yielding no useful knowledge. Table 8 summarizes the research questions concerning the application of IT to knowledge management initiatives.

Summary and Conclusions ▬▬

In this paper, we have presented a discussion of knowledge, knowledge management, and knowledge management systems based on a review, interpretation, and synthesis of a broad range of relevant literature. Several general conclusions may be drawn from our work.

1. The literature review revealed the complexity and multi-faceted nature of organizational knowledge and knowledge management. Different perspectives and taxonomies of knowledge were reviewed and discussed. For example, knowledge may be tacit or explicit; it can refer to an object, a cognitive state, or a capability; it may reside in individuals, groups (i.e., social systems), documents, processes, policies, physical settings, or computer repositories. Thus, no single or optimum approach to organizational knowledge management and knowledge management systems can be developed. A variety of knowledge management approaches and systems needs to be employed in organizations to effectively deal with the diversity of knowledge types and attributes.

2. Knowledge management involves distinct but interdependent processes of knowledge creation, knowledge storage and retrieval, knowledge transfer, and knowledge application. At any point in time, an organization and its members can be involved in multiple knowledge management process chains. As such, knowledge management is not a monolithic but a dynamic and continuous organizational phenomenon. Furthermore, the complexity, resource requirements, and underlying tools and approaches of knowledge management processes vary based on the type, scope, and characteristics of knowledge management processes.

3. KMS, by drawing on various IT tools and capabilities, can play a variety of roles in support of organizational knowledge manage-

ment processes. Specific examples of IT for support of the four knowledge management processes delineated in the paper were presented in the framework section. It is important to note that KMS, by drawing on various and flexible IT capabilities, can lead to various forms of KM support, extending beyond the traditional storage and retrieval of coded knowledge.

4. Research questions regarding organizational knowledge management processes and the role of IT in these processes were presented. These questions could form the basis of future research.

Organizational knowledge and knowledge management are popular topics in several extant literatures including strategic management and organizational theory as well as information systems. It is thus important that IS researchers be aware of, understand, and build upon the already significant work in the large extant literatures. This will provide the diversity of perspectives and approaches that the study of such multifaceted and complex phenomenon requires.

It is our contention that in large global firms in hypercompetitive environments, information technology will be interlaced with organizational knowledge management strategies and processes. This is based on the observation that, in these firms, KM processes span time and geographic distance. This, combined with the need for very short cycle times for product/service development and innovation, necessitates reliance on information and communication technologies. We, therefore, believe that the role of IT in organizational knowledge management ought to receive considerable scholarly attention and become a focal point of inquiry. It is our hope that the ideas, discussion, and research issues set forth in this paper will stimulate interest and future work in the knowledge management area by IS researchers.

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