Chapter 5. Knowledge Management[1]

By Kathryn A. Baker and Ghuzal M. Badamshina

Knowledge management has become such a hot topic that it has been dubbed the business mantra of the 1990s (Halal 1998). The literature primarily addresses the growing importance of knowledge management for private sector organizations, but clearly knowledge-generating organizations such as federal science management and research agencies can not only benefit from this literature but also play a leadership role in furthering theory and practice in this area. Although these knowledge-oriented organizations have been in the business of creating and furthering knowledge development, they have not necessarily developed and articulated a systemic approach to knowledge management. This is a critical omission that should be corrected. Of all the management topics of potential relevance to public science organizations, this may be one of the most useful areas to pursue. Knowledge management is central to public science organizations.

Although knowledge management has become a highly prominent topic, the term remains rather ambiguous and controversial, impeding progress in articulating what knowledge management entails and what knowledge-based organizations will look like. Many have questioned whether knowledge management is, or will ever become, a useful concept with practical application; others proclaim it is already the pivotal driver of organizational success and will only become more important in the future. The latter point of view is persuasive, but there is a long way to go in clarifying and articulating the concept of knowledge management.

The belief that knowledge management is destined to become the key to future economic success is based on the following logic:

1. Many prominent scholars note that a new economic era, referred to as the knowledge-based economy, is already underway. In this new economy, knowledge is the source of wealth. It is assumed, therefore, that knowledge management will be the new work of organizations.
2. Knowledge management represents a logical progression beyond information management. Information technologies, at long last, have demonstrated a notable impact on organizational performance. Many believe that the next generation of information technology/artificial intelligence (IT/AI) products will increasingly enable knowledge management, in contrast to information management, and, as such, will have a far bigger impact on organizational performance (Sveiby 1997).
3. Knowledge management can also be seen as representing a culmination and integration of many earlier organization development ideas (e.g., total quality, reengineering, organizational learning, benchmarking, competitive intelligence, innovation, organizational agility, asset management, supply chain management, change management, etc.). It encapsulates these concepts into a larger, more holistic perspective that focuses on effectively creating and applying knowledge (Amidon 1998:47).

This chapter begins by examining two primary and fundamental questions:

- What is the knowledge-based economy?
- What is knowledge and how does knowledge function as the source of wealth in the knowledge-based economy?

[1] Related chapters include: Science Policy; Strategy; Change Management; Competencies; Innovation.

Only then does it address "What is *knowledge management*?" -- proposing a holistic view of knowledge management that can be applied to both private and public sector organizations. It then discusses how knowledge management could be used to improve science management in the public sector.

This approach is driven by the following observations and suppositions:

1. There is a critical lack of vision in most of the knowledge management literature that stems from the fact the knowledge management discourse is often divorced from any real understanding of the role of knowledge in the knowledge-based economy and the actual dynamics of this new economy.
2. Too often what is discussed under the rubric of knowledge management is merely *information* management.
3. To fulfill the promise of knowledge management, a knowledge vision and strategy is needed that addresses how work systems will be transformed in the knowledge-based economy and how these transformed work systems will, in turn, transform firms, markets, and our economy as a whole. To reach this vision requires a better understanding of both the knowledge-based economy and the role of knowledge in this economy.

A better understanding of knowledge management as it applies to private sector organizations may help to improve knowledge management in public sector science organizations and vice versa.

What is the Knowledge-Based Economy?

Classical economists have characterized economic history as consisting of distinct eras that correspond to shifts in the dominant source of wealth from land to labor to capital. In the 1980s, several prominent theorists, particularly Paul Romer (see Kelly 1996), Machlup (1980-1984), and Drucker (1988), predicted the rise of a new economic era in which knowledge would become the primary source of wealth (see Figure 1).[2]

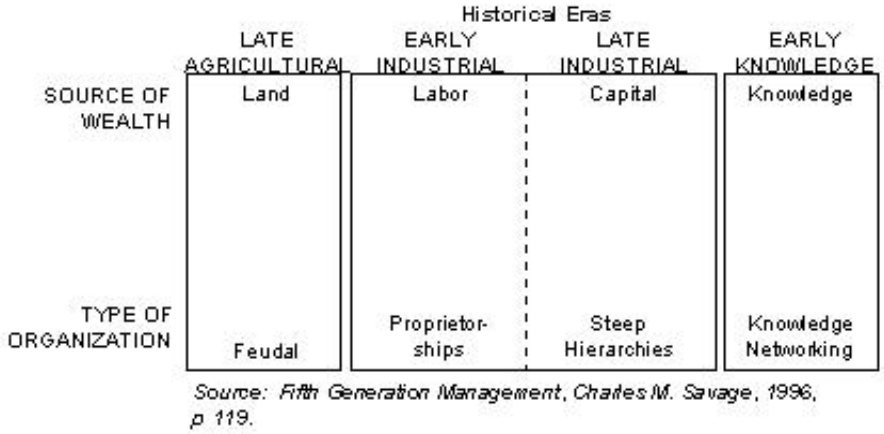


Figure 1. Economic Eras Based on Changes in the Primary Source of Wealth

Knowledge is clearly the primary source of wealth in the high-tech industries (such as the computer and software industries) and other knowledge-intensive industries (such as

[2] In these transitions, the earlier sources of wealth do not disappear but they do become secondary.

pharmaceuticals), but it is fast becoming the primary source of wealth in more traditional sectors of the economy as well (Stata 1989). It is estimated that knowledge now accounts for approximately three-fourths of the value-added in the manufacturing sector (Stewart 1997). This trend is pervading even the oldest sectors of the economy, as such agriculture. Agriculture has been transformed by biotechnology, moving it beyond process innovation to fairly radical product innovation. For instance, corn is no longer a simple commodity but has become a knowledge-intensive product with hybrids rich in cornstarch being developed for industrial users and high oil content strains created for food processors (Stewart 1997). Far more radical knowledge-infused product and service innovations are emerging in all sectors of the economy.

Arguments claiming that a new economic phase is imminent are compelling, but scholars have been less clear in explicating the full implications of this transition. There is a superficial consensus that organizations will have to become more knowledge oriented – a belief that gave rise to the term *knowledge management*. However, there is little in terms of a shared vision regarding the nature of the knowledge-based economy and the function and form of knowledge-oriented enterprises within this new and evolving economy. The transition to a new economic era will no doubt bring about major change. In fact, many expect that this economic transition will have further reaching consequences than any of the prior transitions because, for the first time ever, the source of wealth is not a finite resource that gets used up. Rather knowledge is infinite and boundless and, as a consequence, economies will no longer be constrained by scarcity – a phenomenon that will likely shatter current assumptions about firms and markets (see Kelly 1996).

At a very basic level, it has been argued that in the knowledge-based economy the success of the firm will depend on developing, expanding, protecting, and renewing knowledge and then speeding it to market in a stream of rapidly and continually improved products and services (Stewart 1997). The rate at which organizations acquire, create, and effectively utilize knowledge to produce better products and services will become the only sustainable competitive advantage (Stata 1989). This view focuses on the knowledge outputs, i.e., knowledge-infused products and services. It also suggests the line between services and products will become blurred (Stewart 1997; Davenport and Prusak 1998).[3] While this may be true, the idea that organizations will need to rapidly develop and deliver knowledge-infused products and services does not go very far in detailing how our economic landscape will be transformed.

Hamel (2000) and Malhotra (2000) see the new economy as having at least as much to do with radically new business concepts or models as with new knowledge-infused services and products.

[3] Sveiby (1997:24) thinks that this common line of thinking is mistaken. He makes a distinction between selling knowledge as a package (product) and selling knowledge as a process (service). Though both rely on intangible intellectual assets, the former is driven by *information*, the latter by *knowledge*. The art of achieving increasing returns differs in each case. He believes that much of the confusion concerning how to do business in the knowledge era would probably be eliminated if we had a better understanding of how information and knowledge are similar but different. He suggests that the failure to make this important distinction will lead organizations to make critical mistakes in strategy. Even though the implications of this distinction are difficult to grasp and are not well understood by most persons writing in the area of knowledge management – he argues that most of us can understand that codified knowledge differs from non-codified, non-explicit knowledge. Once knowledge is codified and made explicit, it begins to lose value—at the very least, it no longer has the same dynamic capacity as tacit knowledge to grow. Only tacit knowledge, or tacit knowledge in conjunction with combining multiple sources of explicit knowledge, can enhance existing explicit knowledge. The key to the knowledge-based economy is not knowledge-infused products but tacit knowledge that provides the capacity for these products and for non-codified knowledge services.

The knowledge-based economy will require understanding, rapidly adapting to, and proactively changing the rules of the game and the game itself. Because organizations need to be adept at absorbing, creating, and applying new knowledge in order to thrive in a rapidly changing and unpredictable environment, knowledge management must be oriented toward continually rethinking the business model and identifying new paradigm shifts. The key to future success is for organizations to become ever smarter in coping with and addressing their changing and uncertain environment, avoiding threats, and identifying opportunities. Knowledge management must focus on assessing and creating new organizational concepts and strategy in real-time and forecasting and projecting into the future (i.e., real strategizing must replace strategic planning). These new business concepts:

- Must develop radically new approaches to satisfying customer needs and desires;
- Will entail not only rethinking relationships and transactions between the organization and its customers and suppliers but with other types of organizations, including potential competitor organizations; and
- Will likely require a network-based paradigm shift that defines the value equations beyond the traditional internal value chains and supplier/customer supply chains.

Savage (1996) details how organizational culture, infrastructure, form, and strategy will change. He identifies a host of differences on all these levels that will distinguish organizations across the industrial and knowledge eras, as shown in Figure 2.

Industrial Era	**Knowledge Era**
Order and Stability	Edge of Chaos, Fluidity, and Constant Change
Bureaucratic/Hierarchical	Knowledge Networks/Knowledge Communities
Organizational Boundaries	Interconnectedness
Routine Processes	Complexly Interactive Processes
Sequential Activities	Parallel or Simultaneous Activities
Predefined Structure	Self-organizing
Command and Control	Focus, Facilitate, Coordinate
Vertical Communication	Multi-directional Communication
Instruct/Discuss	Knowledge-Creating Dialogue
Adding Value	Co-creating Value
Distrust	Trust
Known	Unknown
Risk Avoidance	Risk Tolerance
Linear	Non-linear
Individual Skills	Knowledge Competencies
Jobs and Job Specifications	Teaming/Collaboration Capabilities
Compliance	Innovation
Problems	Opportunities
Satisfaction	Meaning

Figure 2. Attributes Characterizing Industrial and Knowledge Era Organizations (adapted from Savage1996)

Badaracco (1991) predicts that entrepreneurial, self-managed units will replace traditional hierarchical structures and that networks of cooperative alliances both within and outside the firm will replace traditional organizational boundaries. This is already occurring. Asea Brown Boveri (ABB) is now comprised of 5,000 self-managed units that interact freely within an internal market, and companies such as Microsoft and Netscape already have organized coalitions or

partnerships between suppliers, developers, manufacturers, distributors, and customers (Halal 1998). Badaracco goes so far as to suggest that organizations will eventually be transformed into fluid networks of alliances and partnerships oriented toward creating, sharing, and applying knowledge. Alliances between suppliers, developers, manufacturers, distributors, and customers will blur the distinction between firms and markets, as well as the distinction between external and internal markets.

These scholars begin to provide a picture of what the knowledge-based economy will entail, but many questions remain. For example:

- Do the facts that knowledge is an infinite resource and that there will be a lack of scarcity in the new economy suggest that competition will eventually disappear or will competition become more intense, as some have argued? Although knowledge, in theory, is infinite, there are limiting factors. Knowledge is neither free, nor freely available. Acquiring and continually renewing knowledge can cost dearly in terms of both time and money and the availability of knowledge can be controlled and restricted.
- If competition does not disappear, will it be primarily oriented toward developing and delivering knowledge-infused products/services or competing in terms of innovative business concepts and models?
- If knowledge alliances and positioning within knowledge networks become critical to future economic survival, will these networks become the new competitive forces?
- Will these knowledge alliances become so fluid that there will no longer be any stable organizational entities as exist today and current notions of firms and markets will be transcended?

What the knowledge-based economy will ultimately become is still very much a mystery. Neither a list of organizational attributes nor the notion of a fluid network is sufficient to clarify how the organizational entities of this new economy will actually look and function. The only thing that is widely accepted is that the knowledge-based economy will be radically different.

The fuzziness of the future does not preclude organizations from transitioning to knowledge-oriented enterprises, but it can make this transition more difficult. Actually, the degree of future uncertainty makes it all the more critical for organizations to have knowledge management systems in place to enhance their ability to successfully address this unknown future. Having a *smart* vision of how they should evolve in this knowledge-based economy can provide organizations with a competitive advantage. This vision is likely to change and improve over time but firms must begin the process of intelligently grappling with their uncertain but rapidly unfolding future prospects.

This chapter posits a vision of the knowledge-based economy that focuses on how the *organization of work* will be transformed. It seems clear that the organization of work will be radically transformed, just as (or more so than) it was in the prior economic transitions. This vision proposes that work systems will become increasingly embedded in knowledge systems. Eventually, these work systems may no longer exist in organizations as we now think of them.

As knowledge systems become more critical and prominent and work increasingly becomes embedded within them, the knowledge systems may become more important organizing entities than the initial organization entities that gave rise to them. Thus, knowledge-based enterprises may become more like knowledge system coalitions (similar to Badaracco's knowledge alliances). Knowledge system coalitions may compete with one another and/or continue to build cooperative networks. They may be more or less fluid than organizations today. Individuals may

compete for membership in these knowledge system coalitions in order to enhance their ability to access to projects and to become part of winning project teams. In addition, knowledge system coalitions may need to compete for the best persons by giving them incentives to be exclusive to the particular knowledge system coalition. Whether or not this long-term vision of the evolving knowledge-based economy is correct, it is clear that, in the near-term, building knowledge systems and embedding work systems within knowledge systems will be an emerging economic reality. Organizations as we now know them may continue to exist for some time, but in their effort to construct and manage knowledge systems, they will increasingly connect and network with other organizations. (See Chapter 9 for a further discussion of this concept.)

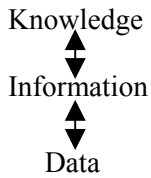
What is Knowledge and How does Knowledge Function as the Source of Wealth in the Knowledge-Based Economy?

Though many of the early theorists (such as Drucker) used the terms *information economy* and *knowledge economy* interchangeably, the distinction between knowledge and information is now strongly emphasized. As a preamble to defining knowledge management, many begin by defining knowledge in a way that clearly distinguishes it from information. But differentiating knowledge from information does not go very far in clarifying what is meant by knowledge or knowledge management. Knowledge is not a unitary concept: there are many forms of knowledge. There are attempts in the more recent knowledge management literature to differentiate *types* and *levels* of knowledge. Some suggest a need to go beyond the concept of knowledge to address *knowledge systems* or *ontologies* in order to understand the full potential impact of knowledge. To make things more difficult, it is not enough to define knowledge; to be effective, managers must understand how knowledge functions in the knowledge-based economy and how exactly it creates or adds value.

What is Knowledge?

Knowledge versus Information

Knowledge, information, and data are often represented as having a hierarchical relationship.



Data are discrete, objective facts about events or objects. Data become information when sorted, analyzed, and displayed in a manner that enables communication via language, graphs, or tables (Davenport and Prusak 1998). Dixon (2000:13) adroitly notes that information is data "in formation." Tiwana (2000), using a catchy alliteration, says information is data that have had value added by having been contextualized, categorized, calculated, corrected, and/or condensed.[4]

[4] Some might argue that some of these transformations, such as contextualization, would blur the distinction between information and knowledge. For example, Quinn et al. (1996) define knowledge as contextualized information.

Knowledge is far more difficult to define and its relation to information far more complex. Some argue that knowledge involves the *link people make between information and its potential applications* and, as such, knowledge is *closer to action* than either information or data (Dixon 2000; Davenport and Prusak 1998).[5] This definition of knowledge corresponds to what many now label *competence*. Because knowledge has so many connotations, Sveiby (1997) prefers the term *competence*. Competence is the capacity to act effectively and efficiently and, according to Sveiby, it is the best way to describe knowledge in the business realm. But many do not confine their definition of knowledge as providing the basis for intelligent action. Knowledge can involve highly abstract cognitive understandings of phenomena that do not necessarily have clear practical applications, at least not in the immediate term. These two views of knowledge parallel the artificial distinction between applied and basic science, a distinction that has been losing ground as applied knowledge is becoming more complex and as private companies and universities are increasingly collaborating to pursue both forms of knowledge.

This distinction between applied and more abstract knowledge is actually a continuum and does not go far enough to explicate the role of knowledge in organizations or in the knowledge-based economy. Moreover, both types of knowledge are important to organizations today. Basic fundamental knowledge or science often is essential for promoting innovative research and development (R&D); applied knowledge is thought to be important to promote efficient and effective organizational operations. A better understanding of the levels and types of knowledge may be necessary to understand the role of knowledge in the knowledge-based economy.

Levels of Knowledge

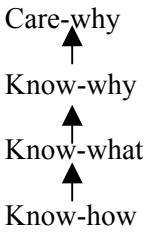
Knowledge can be seen as occurring at various levels. For instance, knowledge can exist at lower, practical levels (close to action) as well as at higher, theoretical levels (focused on high level understandings that, as yet, have little relation to practical action). A common way of characterizing levels of knowledge is to see knowledge as progressing from identifying *attributes* of concepts, to establishing *relationships* between concepts, to specifying the *conditions* under which these relationships apply. A similar view characterizes knowledge as progressing from *relational* thinking to *systems* thinking and, within systems thinking, as progressing from *identifying system characteristics*, to *detecting system trends*, to *explaining system dynamics*. Nonaka and Takeuchi (1995) see knowledge as moving from lower level, general forms to higher level, more precise forms (for example, from simple slogans, to similes and metaphors, to systematic analogies, to structured models and theories). Lower level knowledge (slogans, similes, and metaphors) provides insightful, albeit imprecise, understandings that can help generate higher level, more systematic and explicit knowledge (analogies and, eventually, highly structured and precise models and theories).

Distinguishing lower from higher levels of knowledge may also equate to distinguishing between discrete knowledge elements or statements versus knowledge systems. Going beyond knowledge elements to build knowledge systems can be seen as a qualitatively higher level of cognitive activity. Knowledge systems can be ontological systems, frameworks, theories or models that not only *show relationships, suggest connections, facilitate comparisons, and predict consequences* but also can be used to *interpret and incorporate new experiences and information*. They can involve dynamic, on-going processes that involve *seeing and categorizing existing patterns and*

[5] Sveiby (1997) also sees knowledge as closer to action than information but he also sees knowledge as action. Knowledge is the act of knowing and involves learning, forgetting, remembering, and understanding. Information, on the other hand, is not action.

relationships and envisioning/predicting new ones, and as providing an *understanding of the particular within the context of the whole*. As such, chaos theory, complexity theory, fractals, general systems thinking, and related topics have been prominently featured in the knowledge management literature (Savage 1996). It may be that high level knowledge systems can help inform action in complex and uncertain situations better than more specific knowledge applications.

The above definitions of knowledge have focused on its rational aspects. Quinn et al. (1996) note that knowledge contains other aspects, such as values and moral judgments, that are ignored by these definitions. They assert that taking into account the non-rational (not to be confused with irrational) aspects of knowledge is the highest order of knowing, as indicated in their following hierarchy of knowing:



Know-how is knowledge of how to do things and corresponds to what Dixon (2000) refers to as "common knowledge." *Know-what*, or cognitive knowledge, goes beyond basic skill competencies and experience to a higher level mastery of a knowledge domain or problem area.[6] *Know-why* requires a deeper understanding of interrelationships across knowledge areas – it may require a systems perspective and provides a more robust knowledge framework for grounding decisions and actions in complex, uncertain contexts. *Care-why* requires socially contextualized knowledge – such as understanding relevant values and their salience for different stakeholder groups. This highest level of knowledge might address direct and hidden, near- and long-term cost/benefit differentials associated with alternative strategies from the perspective of different stakeholder groups as well as an assessment and evaluation of possible contingencies, tradeoffs, and compromises. It is this level of understanding that provides the basis for negotiation and conflict resolution that can inform collective decision making and action.

Types of Knowledge

In addition to levels of knowledge, Nonaka and Takeuchi (1995) distinguish between two types of knowledge – explicit and tacit.[7] Explicit knowledge refers to intellectual artifacts (books, documents, manuals, theories, models, simulations and their interpretations, mathematical expressions, tables, graphs, databases, and so on). It encompasses all levels of cognition

[6] Alternatively, a combination of *know-what* and *know-who* is seen by some as the first tier of knowledge. Often an organization begins its knowledge management practices at this initial level, such as developing yellow pages of technical inventories (what) and the corresponding experts/points of contact (who).

[7] Michael Polanyi recognized the importance of this distinction and developed a theory of tacit knowledge in the 1940s-50s. He claimed that the tacit knowledge that underlies explicit knowledge is more fundamental in that all knowledge is either tacit or was initially rooted in tacit knowledge. Further, tacit knowledge, and thus all knowledge, cannot be objective. Because it is constructed by humans, it contains emotions and passions which can never be fully accounted for by a set of articulated rules or algorithms. Polanyi also distinguished between tacit and focal knowledge. Focal knowledge is knowledge about an object or phenomenon that is being focused on; tacit knowledge is the general background knowledge that is used to create focal knowledge.

(including information and data) that can be put into visual presentations, words, or numbers. Tacit knowledge refers to cognition that resides in people's heads, such as cumulated wisdom and understanding, institutional knowledge, organizational lore, and basic orientations. It also includes personal knowledge embedded in individual experience in the form of rules of thumb, values, preferences, intuitions, and insights.

As shown in Figure 3, Nonaka and Takeuchi assert that the four conversion processes involving these two types of knowledge constitute the essence of knowledge creation:

- From tacit to tacit (i.e., socialization),
- From tacit to explicit (i.e., externalization),
- From explicit to tacit (i.e., internalization), and
- From explicit to explicit (i.e., combination).

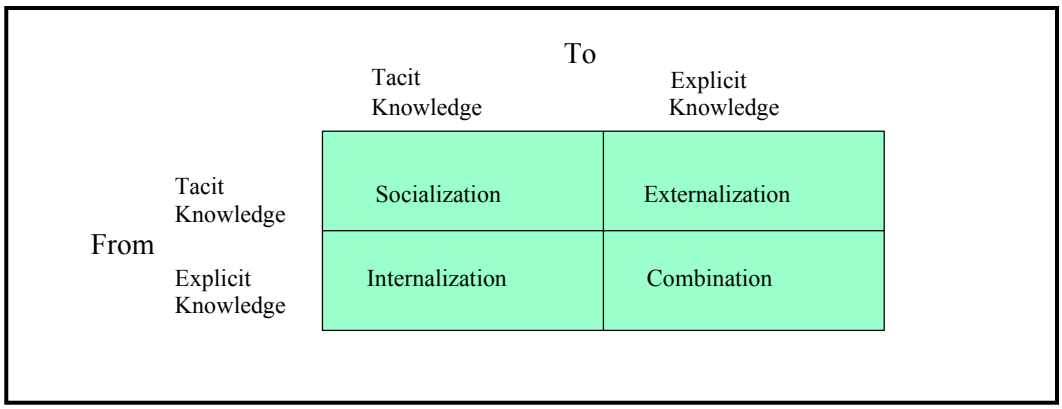


Figure 3. Human Processes Corresponding to Knowledge Conversion Processes

They further claim that conversions between tacit and explicit knowledge are particularly important. Only by tapping into tacit knowledge can new and improved explicit knowledge be created. In turn, better explicit knowledge is essential for stimulating the development of new, higher level, tacit knowledge.

Although knowledge management has tended to focus on improving and managing explicit knowledge (e.g., artifacts), Nonaka and Takeuchi argue that this is not where the emphasis ought to lie. Knowledge creation and application require far more than well-structured knowledge artifacts. But because tacit knowledge is difficult to formalize, make explicit, and manage, it has been overlooked by organizations. But tacit knowledge, especially high level tacit knowledge, will become increasingly important as organizations face the ever pressing need to create new knowledge. Also, as organizations develop more systematic practices and techniques to foster this knowledge and to facilitate its conversion to explicit knowledge, tacit knowledge will no longer be seen as "unmanageable." The advent of expert systems and some CAD/CAM approaches are systematic ways to codify tacit knowledge.

Some scholars claim that knowledge only resides within (and between) the minds of individuals (i.e., Sveiby 1997). They often use the term *tacit knowledge* to capture this notion. In their view, once knowledge has been explicitly captured (i.e., documented), it is merely information. Nonaka and Takeuchi do not equate the distinction between tacit and explicit knowledge with the distinction between knowledge in the minds of individuals versus knowledge that is explicitly documented, nor do they confine the term knowledge to mean the former. Rather, they see tacit knowledge as

knowledge that is not yet fully articulated and systematized in the minds of individuals – such as notions, impressions, experiences and cumulated wisdom – and, as such, is difficult to explicitly document. In this sense, tacit and explicit knowledge can be seen as a continuum ranging from more or less tacit (or more or less explicit).

Although capturing tacit knowledge and converting it to explicit knowledge and vice versa may constitute an essential source of knowledge creation, tacit to tacit knowledge conversions and exchanges are likely to extend far beyond socialization. Persons sharing what they know and, especially, struggling together to further develop and systematize what they do not yet explicitly know, is not adequately captured by the notion of *socialization*. This interpersonal exploration and development of tacit knowledge, which often can be explicitly articulated only after considerable effort, is generally seen as the primary source of new knowledge creation (Sveiby 1997).

The Value of Knowledge in the Knowledge-Based Economy

Malhoutra (2000) suggests that data, information, and even knowledge often have little value. Newspapers, periodicals, and knowledge-oriented web sites typically do not make money by selling their knowledge content to consumers; they make money by selling advertisement space to others who want to disseminate particular information to these consumers. The key is to determine what makes knowledge valuable and, in particular, how knowledge creates wealth in the new knowledge-based economy. While some suggest that infusing knowledge into products and services is what makes knowledge valuable, a stronger contention is that building the knowledge systems that allow for product and service innovation is the key to creating value and wealth.[8] In addition, knowledge systems that inform business concepts/models as well as those that inform operational processes are also critical. Basically transforming work systems at all levels by embedding them within appropriate and effective knowledge systems is what adds value and creates wealth for the organization.

Many work systems require complex, multidisciplinary knowledge systems to promote effective decision-making and action: scientific work systems constitute an excellent example of this. Constructing knowledge systems, facilitating links between diverse knowledge systems, and embedding work systems within knowledge systems should become increasingly important topics in knowledge management. If knowledge systems are based on a common ontological structure, higher level ontologies can be abstracted across diverse knowledge domain ontologies to support dialogue and scientific exploration across these knowledge systems. These abstracted ontologies can be designed to support links ranging from superficial to more sophisticated levels. Constructing inter-relating knowledge systems and embedding work systems within these knowledge systems is the likely key to the future of knowledge management.

What is Knowledge Management?

The term *knowledge management* was first introduced in a 1986 keynote address to a European management conference (American Productivity and Quality Center 1996). This term had immediate and vast appeal and, at the same time, spawned strongly felt criticism.

[8] The key to the knowledge-based economy is not knowledge-infused products but tacit knowledge that provides the capacity for these knowledge-infused products and for non-codified knowledge services (Sveiby 1997).

A Critique of Knowledge Management

The major criticisms of knowledge management are that:

- It has traditionally conjured up too close an association with information management and information technology (IT).
- It implies that knowledge can be managed.
- It tends to be so broad and vague as to have little meaning.
- It tends to focus on the nuts and bolts of knowledge creation, capture, sharing, use and reuse, rather than providing a true vision and strategy that conveys how knowledge-based enterprises will function and succeed in the new knowledge-based economy.

In addition, more specific criticisms have been leveled at particular views of knowledge management. The most common type of definition describes knowledge management as a set of processes directed at *"creating-capturing-storing-sharing-applying-reusing"* knowledge (Sydanmaanlakka 2000). This type of definition is criticized for making knowledge management appear to involve somewhat mechanistic and sequential process steps and for focusing attention on explicit knowledge artifacts as opposed to tacit knowledge. Knowledge engineering reflects this view of knowledge management. A definition with similar problems sees knowledge management as *"delivering the right knowledge to the right persons at the right time."* This definition emphasizes explicit knowledge artifacts over tacit knowledge and ignores knowledge creation.

Alternative definitions have been proffered that attempt to better capture the complexities of knowledge and knowledge management. For example, Snowden (2000) defines knowledge management as:

> The identification, optimization, and active management of intellectual assets, either in the form of explicit knowledge held in artifacts or as tacit knowledge possessed by individuals or communities. The optimization of explicit knowledge is achieved by the consolidating and making available of artifacts. The optimization of tacit knowledge is achieved through the creation of communities to hold, share, and grow the tacit knowledge. The active management of intellectual assets is the creation of management processes and infrastructure to bring together artifacts and communities in a common ecology that will sustain the creation, utilization and retention of intellectual capital.

This definition, though a bit cumbersome, recognizes that knowledge management must address both explicit and tacit knowledge, as well as the interaction between the two, and begins to address some of the mechanisms for doing this. It does not, however, capture all aspects of knowledge management, nor does it address how knowledge will be used or how a knowledge-based enterprise will ultimately function and/or look.

The problems with the term *knowledge management* can be overcome if one thinks of knowledge management as building and enhancing knowledge systems and embedding work systems within these knowledge systems, rather than managing something as nebulous as knowledge per se. Thus, an appropriate definition of knowledge management would be creating *knowledge-rich environments and knowledge-rich interactions in the conduct of work*. More specifically, knowledge management is *developing and managing integrated, well-configured knowledge systems and increasingly embedding work systems within these knowledge systems.*

Defined in this way, knowledge management does not over-emphasize IT. It is clear that both knowledge systems and the processes of embedding work systems within knowledge systems can be managed. Finally, this definition is broad enough to capture all aspects of knowledge management but is not overly vague – one can define, with some precision, what a knowledge system is. One can also articulate how work systems can become embedded within knowledge systems. In addition, more specific knowledge systems and corresponding work systems can be specified for particular contexts. While an organization may vary in the extent to which it develops full-fledged and integrated knowledge systems and embeds work systems within these knowledge systems, all organizations need to direct greater attention to assessing and improving their knowledge systems and linking work processes to these knowledge systems.

However, this definition does overly attend to the nuts and bolts of knowledge management to the point of ignoring the bigger picture. It leads to an enterprise-wide vision – a view absent in the literature and in organizations, although there is a recognized need for both vision and strategy. The vision of building knowledge systems and embedding work systems within them encourages the whole spectrum of on-going, dynamic, interrelated knowledge-oriented activities to be taken into consideration, while making it impossible to reduce knowledge management to a set of discrete, mechanistic knowledge management practices. This view of knowledge management enables the organization to identify its critical knowledge domains, its most immediate and future knowledge priorities, goals and objectives, and to work toward building critical knowledge systems and embedding work systems within them. Finally, it helps the organization identify the most appropriate set of knowledge management practices, determine how information technology (IT) and artificial intelligence (AI) can best enable these well-configured, integrated enterprise-wide knowledge systems and embed work systems within them.

A Critique of the Practice of Knowledge Management

Backlash to the term *knowledge management* seems not to have arrested the growing surge of interest in and adoption of knowledge-oriented practices by organizations. However, the practice of knowledge management suffers from the same problems as the literature. So-called knowledge management practices are often little more than renamed information management. Even though the knowledge management literature now clearly stresses the difference between information and knowledge, knowledge management practices often fail to follow suit. Knowledge management activities have typically been directed at the nuts and bolts of knowledge management, as opposed to developing a vision and strategy for knowledge management.

The American Productivity and Quality Center conducted the first major knowledge management benchmarking study in 1996. This study found that knowledge management was a highly recognized and prominent term, that it was becoming a major consulting thrust for several prominent international consulting companies, and that companies in all sectors had initiated a variety of knowledge management activities. A more recent survey of 200 senior executives (described in Hackett 2000) found that:

- 80 percent of the senior executives reported that they had some knowledge management efforts underway
- 25 percent had a chief knowledge management officer or chief learning officer (though half were not supported with a dedicated budget or staff)
- 21 percent had an articulated knowledge management strategy

- Only 6 percent had a holistic, enterprise-wide knowledge management vision and strategy (however, 60 percent expected that they would have an enterprise-wide knowledge management vision and strategy in place within 5 years).

Overview of Knowledge Management Practices

There is a growing body of literature documenting the types of knowledge management projects being undertaken by organizations (see Davenport et al. 1998a; Horibe 1999; Leonard-Barton 1998; Sveiby 1997; Schrieber et al. 2000; Wenger 2000). Also, the Institute for Knowledge Management (which includes Boston University, Stanford University, the Wharton School, The Brooking Institute, University of Texas, and Theseus in France) has compiled a resource library on knowledge management practices and outcomes. Common knowledge management practices include:

- Creating and improving explicit knowledge artifacts and repositories (developing better databases, representations, and visualizations; improving the real-time access to data, information, and knowledge; delivering the right knowledge to the right persons at the right time)
- Capturing and structuring tacit knowledge as explicit knowledge (creating knowledge communities, knowledge networks, alliances, and partnerships; supporting knowledge communities and networks with electronic tools to capture knowledge and convert tacit knowledge to explicit knowledge)
- Improving knowledge creation and knowledge flows (developing and improving organizational learning mechanisms; facilitating innovation strategies and processes; facilitating and enhancing knowledge creating conversations/dialogues)
- Enhancing knowledge management culture and infrastructure (improving participation, motivation, recognition, and rewards to promote knowledge sharing and idea generation; developing knowledge management enabling tools and technologies)
- Managing knowledge as an asset (identifying, mapping, analyzing and assessing the relevant knowledge landscape; identifying, documenting, measuring and assessing intellectual assets; identifying, prioritizing, and evaluating knowledge development and knowledge management efforts; documenting and more effectively leveraging intellectual property)
- Improving competitive intelligence and data mining strategies and technologies.

Attention has been primarily directed to the following knowledge management practices.

- *Knowledge Communities, Communities of Practice, and Knowledge Discourse*: Knowledge communities and communities of practice are considered by many to be the critical essence of knowledge management (Savage 1996; Wenger 1998; Wenger and Snyder 2000; Stewart 1997). The difference between a knowledge community and a community of practice is that, in the latter, the primary focus is on the conduct of some specific set of work practices, rather than on creating and sharing more generic knowledge that may have some potential future application and utility. Using Polanyi's distinction (see footnote 4), communities of practice are directed at focal knowledge (an immediate concern), while the goal of knowledge communities is to enhance more generalizable, tacit knowledge. Although communities of practice in today's organizations are becoming more explicitly knowledge-oriented, knowledge communities are often necessary supplements. Knowledge communities and, oftentimes, communities of practice are fluid and interpenetrating (as opposed to bounded), crossing the restrictive boundaries of the organization to incorporate

people from many organizational realms as well as people outside the organization (Brown and Duguid 1991).

Knowledge communities and communities of practice are critical because they capture and cultivate the scarcest resource in business today – human attention (Davenport and Prusak 1998). Von Krogh et al. (2000) see directed and managed knowledge discourse (dialogue), much of which occurs within knowledge communities and communities of practice, as the most important work of organizations. Persons who are good conversation managers and knowledge organizers are likely to become the most valuable intellectual assets in the organizations of the future. In addition, advanced IT and AI should greatly facilitate knowledge discourse, and not necessarily just electronic discourse. Areas to develop include (1) automated systems that effectively capture and organize knowledge creating dialogue in real time and (2) ontological systems that facilitate the ability to communicate across diverse in-depth knowledge domains. Dialogue across in-depth knowledge domains has been called *T-form*, but should perhaps more accurately be called *ladder-form* communication to represent the need to communicate across these domains at progressive levels of depth. More and more companies are stewarding their knowledge resources by using knowledge communities, knowledge-oriented communities of practice, and knowledge discourse, including AMS, J&J, Shell, Daimler-Chrysler, the Veterans Administration, Hewlett Packard, IBM, McKinsey, Hills/Colgate, and National Semiconductor.

- *Knowledge Networks**:*** Organizations, particularly those that are highly knowledge oriented, such as universities, research centers, and high tech organizations, are directing greater attention to establishing knowledge alliances or partnerships with other organizations. It has become more difficult for any single organization to develop internally all the capabilities it needs. Supplementing existing knowledge via the market is often not feasible because frequently the requisite knowledge does not exist—rather it must be created to meet highly specific knowledge goals and applications in conjunction with those who possess specific understanding of these goals and applications. Further, in the formative stages of knowledge creation, knowledge tends to be tacit (held in the minds of the scientists). It is also frequently dense (in-depth, complex, and highly intricate). The market is not a good transfer mechanism for tacit and/or dense knowledge (Liebeskind et al. 1996). Thus, as the required knowledge base of an industry expands and becomes more multifaceted, the sources of expertise will become more widely dispersed and the locus of creativity and innovation will increasingly be found in networks of organizational alliances rather than in individual firms (Powell et al. 1996). To succeed in this new knowledge-based economy, organizations must go beyond developing their internal ability to identify and utilize existing knowledge; they must develop their capacity to form and manage collaborations to create and apply knowledge (Powell et al.1996). Rogers and Bozeman (2001) propose the terms *knowledge value alliances* and *knowledge-value chains* as a way of looking at knowledge relationships and networks both within and across organizations.
- *Knowledge Landscapes:* This is a metaphorical notion that emphasizes the utility of creating a knowledge picture (typically a map) of the relevant knowledge domains and their relative importance (sometimes displayed as smaller and larger knowledge peaks). In addition, it may include an attempt to map the interrelations between the peaks as well as to document and map the current versus the desired states of these knowledge domains and their interconnectivity. The construction of a knowledge landscape along with detailed mapping and documentation of the content and respective strengths of each peak can facilitate exploratory navigation through the landscape to identify possible links across knowledge domains, knowledge gaps and needs, etc. Finally, it is important, but

not easy, to identify and distinguish between knowledge that needs to be preserved and shared and that which is no longer useful and should be discarded. Discarding obsolete information and unlearning certain practices is as much a part of knowledge management as is creating and capturing new knowledge. As John Maynard Keynes once said, "The greatest difficulty lies not in persuading people to accept new ideas, but in persuading them to abandon old ones." Leonard-Barton (1995) and Christensen (1997) both discuss the notion of core capabilities becoming core rigidities. Knowledge landscapes and other conceptual tools can greatly aid in determining the types of knowledge communities, networks, and alliances that will produce the greatest value. European companies have demonstrated particular interest in knowledge analysis and mapping.

Toward an Enterprise-wide Knowledge Management Vision and Strategy

Identifying various knowledge management practices is not adequate guidance to companies interested in promoting and fostering their knowledge capability. A holistic enterprise-wide vision and strategy are needed to meet this need. But as noted, integrated, holistic approaches for building and managing knowledge-based enterprises are largely absent not only in practice but in the literature. Some theorists have discussed what an enterprise-wide approach to knowledge management would have to entail – such as an overall knowledge-oriented vision, strategy, culture, processes, infrastructure, and structure (Morris 1999; Tissen et al. 1998; Devlin 1999), but they fall short of actually proffering a concrete, holistic model. Figure 4 delineates the critical elements of a holistic and integrated knowledge management model and shows how these elements fit together. This model moves beyond the basic ideas of vision/strategy, leadership, measurement and analysis, resources and infrastructure, structure and processes to elaborate what is entailed in each of these areas and to provide a visualization of a holistic knowledge management model.

The model in Figure 4 focuses on actual tangible elements of a holistic approach to enterprise knowledge management, in contrast to the intangible knowledge conversion processes (socialization, internalization, externalization) that Nonaka and Takeuchi (1995) emphasize. These tangible elements include:

- Specified knowledge goals, objectives, priorities
- Transformation plans to transition from "as is" to "to be"
- An articulated knowledge landscape
- Measures and assessments of the state of knowledge and the knowledge management system
- Knowledge leaders, advocates, activists, and facilitators (these persons will be assigned to various communities of practice, knowledge communities, innovation initiatives and projects; they will be in charge of developing and maintaining knowledge networks; they will be responsible for further articulating of the knowledge landscape and for measuring and assessing the state of knowledge and the knowledge system)
- Knowledge-oriented IT, AI, and communication technologies (CT)
- Tacit knowledge assets as represented by actual human beings (internal staff and external collaborators) and established processes to facilitate interactions between them
- Explicit knowledge assets as represented by enterprise information systems, enterprise knowledge systems, databases, IP, and other knowledge artifacts
- Competitive intelligence and benchmarking activities

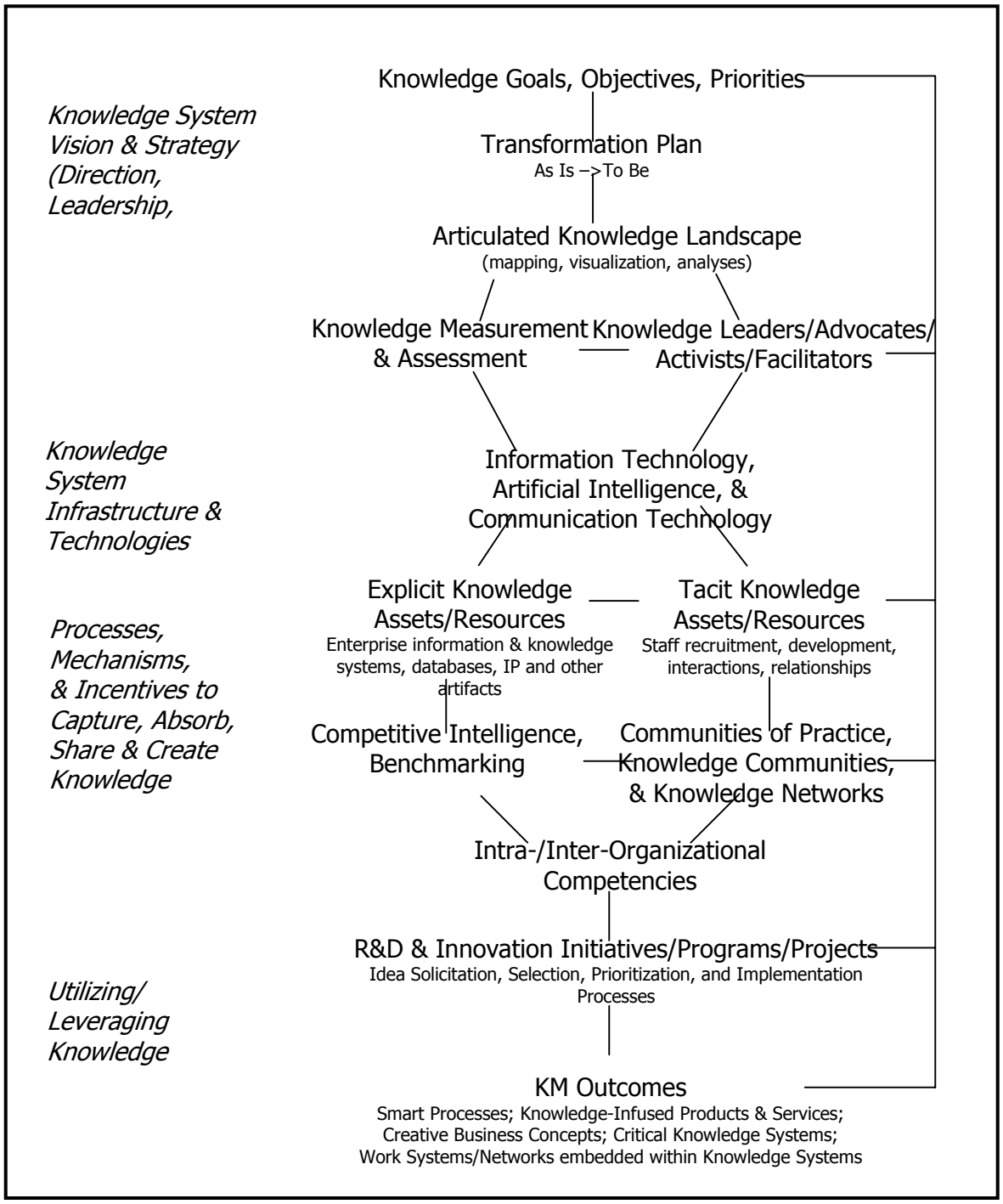


Figure 4. Integrated Knowledge Management Model: Components and Linkages

- Communities of practice, knowledge communities, and the knowledge partnerships and alliances comprising knowledge networks
- Intra- and inter-organizational competencies
- R&D and innovation programs, initiatives and projects
- Knowledge management outcomes, including smart, knowledge-infused processes; knowledge-infused products and services; creative business concepts; critical knowledge systems; and work systems embedded within knowledge systems.

It is these tangible components of knowledge management that give rise to the important intangible attributes – such as the level, range, and depth of tacit knowledge, individual competencies, intra- and inter-organizational competencies, a knowledge-oriented culture, knowledge leadership, knowledge socialization, internalization, and externalization. Focusing on the tangible components helps knowledge management become a reality as opposed to a vague concept that is difficult to grasp and put into practice. The human elements of the enterprise knowledge management system provide critical feedback opportunities. Knowledge leaders, advocates, activists, and facilitators, tacit assets (staff in general), members of the various communities of practice, knowledge communities, and key network development staff, key R&D staff, and innovation program and project staff are all critical sources of input and feedback for improving and advancing the enterprise knowledge management system.

Stages of Knowledge Management

There has tended to be a progression of knowledge management goals and stages:

- Stage 1—*Smart Processes*: Knowledge management activities often initially focus on improving processes (focusing on continuous improvement through lessons learned, best practices, process innovation, getting the right information/knowledge to the right people at the right time, etc.). Many e-business initiatives are merely speeding up existing processes by enhancing the flow of information and data, such as electronic ordering, providing product and service information and support over the internet, and promoting just-in-time delivery. These process-oriented improvements can eventually focus on developing more knowledge-infused, smart processes. For example, the ordering process can assist the customer in more exactly determine the product(s) needed and estimate the amounts required for a particular project.
- Stage 2—*Knowledge-Infused Products and Services*: The focus next turns toward creating new and increasingly knowledge-infused products and services (with an emphasis on enhancing creativity and more effective and efficient R&D).
- Stage 3—*Innovative Business Concepts*: Attention, at least in the literature, has most recently been directed at developing new business concepts (changing the rules of the game and the game itself).
- Stage 4—*Constructing Critical Knowledge Systems and Conjoining Work Systems with Knowledge Systems*: The ultimate goal of knowledge management is to construct and continually enhance knowledge systems and to conjoin knowledge systems and work systems. All levels of work should be embedded within the appropriate knowledge systems, including strategic decision-making, operations, R&D, engineering, maintenance, marketing, etc. Building better and better knowledge systems and conjoining work systems with these knowledge systems is the on-going motor of innovation. The challenge is to determine what knowledge systems are critical to the various work systems and constructing these to facilitate and improve work system

processes and decision-making activities. Enhancing knowledge systems will inevitably lead to knowledge partnerships and knowledge system coalitions. These inter-organizational knowledge systems will need to managed and led.

If knowledge management outcome goals are restricted to smart processes, smart products and services, and new business concepts, the knowledge management literature is not distinguishable from the innovation literature. The innovation literature clearly addresses these three forms of organizational innovation. Knowledge management can be distinguished from innovation by focusing on how work systems will be transformed by embedding them within knowledge systems. Eventually these knowledge systems may cause work systems to transcend traditional organizational boundaries. The literature on virtual organizations has long predicted that organizations would evolve into projectized work efforts, such as making a film, where the best set of individuals are brought together temporarily to work on a particular project. The management and leadership of the knowledge systems could function like the big movie production houses in that they would influence the types of projects that get sponsored and bring together the appropriate project teams and facilitate the performance of these project teams. It may be that knowledge-based organizations gradually become networks of knowledge-based organizations and that, eventually, these networks evolve into knowledge system coalitions that by and large replace organizations as we know think of them today.

Challenges in Implementing an Enterprise-Wide Knowledge Management Model

How to Begin?

Abstractly designing a holistic enterprise-wide knowledge management system, as done in Figure 4, may not be particularly difficult – putting it into practice is. The saving factor is that it does not have to be implemented all at once. An integrated knowledge system can gradually take form with proper organizational direction, facilitation, and support. One of the entry points to stimulating the formation of a holistic knowledge management system is to encourage employees to develop and participate in knowledge communities. Organizational managers and leaders must facilitate the development of these knowledge communities to the point that a knowledge landscape begins to form, knowledge gaps are identified, and priorities are established. The existence of active knowledge communities will build momentum and help to push activity on the other fronts. As noted earlier, these communities help solve the biggest obstacle: capturing and harnessing human attention. If knowledge communities are given enough support and direction, the rest should follow. However, it is important that the transformation plan be made explicit and that it be supported and sustained by all the necessary organizational leaders.

Cultural Challenges

A second issue in implementing a holistic knowledge management system is to ensure that these initial knowledge communities do not become knowledge hoarding gatekeepers. It is important for the organization to value, reward, and motivate knowledge creation, knowledge sharing, knowledge inclusion and broad-based knowledge engagement. At the enterprise level, there are real issues regarding balancing a culture of openness and knowledge-sharing with the need to appropriate knowledge as intellectual property.

Infrastructure Challenges: IT, AI, and CT Enablers

Although knowledge-oriented technologies are shown as a discrete element of the knowledge management model, these technologies are essential to enable (1) most elements of the model, (2) the linkages between these elements, and (3) the knowledge management system as a whole. Advanced IT and AI should facilitate:

- Articulation, mapping, and visualization of the knowledge landscape
- Measurement and assessment of knowledge states, goals, objectives, and activities as well as the knowledge system as a whole
- Characterization and mapping of individual knowledge competencies
- Characterization and mapping of intra- and inter-organizational knowledge competencies
- Accessibility and utility of explicit knowledge resources
- Effective processes and systems for conducting competitive intelligence
- Real-time capture, organization, and management of knowledge discourses
- Knowledge exchanges between diverse knowledge domains at various levels of depth
- Knowledge network design, mapping, and maintenance (addressing both intra- and inter-organizational knowledge collectivities and knowledge-value chains a la Rogers and Bozeman 2001)
- Automated and faster R&D (virtual simulations, etc)
- Innovation teamwork and faster innovation cycles (groupware applications for distributed as well as co-located and asynchronous as well as synchronous team interactions).

Enabling Linkages among Elements of the System

The linkages between system elements are not shown in their entirety in Figure 4, as it would be too messy. The lines connecting system elements would look like a spider's web. Advanced IT, AI, and CT are necessary to facilitate 2-way knowledge interaction and exchanges between knowledge management system components, such as between knowledge communities, communities of practice, knowledge leaders, advocates, activists, and facilitators, competitive intelligence, benchmarking, knowledge landscaping, articulating competencies, R&D and innovation programs and projects. Also IT, AI, and CT enable the conversion of tacit knowledge into explicit knowledge resources and vice versa.

Enabling the Knowledge Management System as a Whole

System-wide knowledge-oriented technologies are becoming more critical for managing today's complex organizations. The most common of these are enterprise information management systems, enterprise asset management systems, enterprise value-chain management systems, and enterprise product platform and product life cycle systems. While these systems make up parts of a complete knowledge system, a higher-level framework that integrates these systems into a holistic knowledge management system should be developed in the future.

The Application of Knowledge Management to Public Science Management

Most knowledge management issues are as applicable to the management of public sector organizations as to the management of private sector enterprises. In fact, it would seem that traditional knowledge-oriented organizations, such as universities, research and development laboratories and public sector science funding and directing organizations, should play a lead role in developing and furthering the theory, practice, and tools to promote better knowledge management.

Although there is substantial overlap across types of organizations, the particular knowledge management challenges facing public science funding and directing organizations will differ some from those confronting public science executing organizations, and in both cases these challenges should differ somewhat from those of greatest concern to private sector enterprises.

The biggest knowledge management challenges for public sector science funding and directing organizations might include:

- Mapping and assessing various knowledge domains (recognizing that these domains often span the traditional disciplines) to determine where knowledge gaps/needs exist as input to establishing research agendas and funding priorities
- Having the knowledge to effectively inform the strategic direction of scientific research advancements toward solving our most critical health, security, environmental, and social problems
- Promoting collaboration among various science funding and directing organizations (primarily but not exclusively those in the public sector) to achieve greater efficiency, effectiveness, and synergy among these organizations as well as among science performing organizations
- Enabling the capture and sharing of knowledge across science organizations, particularly among public sector science organizations
- Balancing the goals of sharing knowledge among public science organizations and demonstrating organizational performance accountability by claiming credit for new scientific developments
- Developing effective and useful knowledge systems to deliver knowledge to various user groups and to both general and specific stakeholders—these knowledge systems can be used to provide interested persons with information regarding the organization's performance accountability and the benefit of the public money expenditures, to allow interested persons to obtain information on recent scientific breakthroughs and their import or to identify the state of knowledge in particular areas, etc.
- Promoting partnerships between the public sector research and development laboratories, private sector research and development efforts, and universities to enhance knowledge creation and share the cost/risk of major science initiatives
- Promoting international scientific partnerships and global scientific advancement;
- Promoting the utilization and commercialization of publicly funded science
- Encouraging and facilitating good knowledge management practices in public sector, as well as private sector, science executing organizations; and providing direction in building knowledge-rich environments and knowledge-rich interactions in the conduct of science.

The biggest knowledge management challenges for public sector science executing organizations might include:

- Enhancing their capacity to identify and become leaders in cutting-edge science
- Creating knowledge-rich environments and knowledge-rich interactions to promote the conduct of science
- Developing an effective science portfolio and an effective pipeline of projects, recognizing the tradeoffs between overlap and efficiency
- Facilitating the proprietary capture of new science developments/discoveries as intellectual property
- Determining how to develop knowledge systems that adequately capture the state of knowledge in various scientific domains and can be easily utilized
- Determining how to make links across diverse knowledge systems
- Balancing the goals of generating intellectual property and sharing knowledge freely to advance rapid and effective scientific development
- Identifying and managing critical knowledge competencies and assets
- Expanding their knowledge-base and critical competencies through strategic partnerships/alliances
- Establishing processes to better foster knowledge creation and innovation.

Science performing organizations can basically apply the holistic knowledge management model in Figure 4, except that the goals may differ somewhat. Instead of embedding work systems within appropriate knowledge systems, the goal in federally funded research organizations would be to embed the conduct of science and scientific decision-making within appropriate, well-designed science knowledge systems. The knowledge management system required by science directing and funding organizations might be somewhat more restricted. They may only need knowledge systems that enable their ability to assess, evaluate, and inform strategic decision-making that will contribute to bringing about a more effective and efficient national science system. These latter organizations, however, need to encourage or require knowledge dissemination and knowledge systems as part of funded research.

Unlike the organizational transformations characterizing prior major economic shifts, the transition to the knowledge-based economy will indubitably be faster and will exert intense pressure on organizations to take charge and stay ahead of the competition. For this reason, organizational transformation will need to be directed and facilitated, rather than a slow emergent phenomenon, as in the case of these earlier economic transformations. This does not mean that organizations need to implement a full-blown knowledge management system all at once, but they must aggressively promote and direct the progressive formation and continual improvement of this system.

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