Information Systems as a Conduit for the Transfer of Knowledge

Laurence Prusak
Director of IBM Institute for Knowledge Management

Salvatore Parise
Research Consultant

Abstract

There is little doubt that information technology (IT) has been a central part of the knowledge management movement, often providing the personnel, expertise, and infrastructure needed to transfer knowledge within and across organizations. However, what is less clear is the role that IT plays across different knowledge management activities. It has been argued that technology's most valuable role in knowledge management is extending the reach and enhancing the speed of knowledge transfer. Information technology has proven to be very useful in capturing, storing, and distributing structured and codified knowledge, therefore enabling other individuals in the organization to have access to it. However, IT, by itself, cannot create a knowledge-based environment that promotes knowledge use and sharing. For any technology to be optimized, it must be augmented by strategies, processes, a culture, and behavioral norms that support knowledge sharing and knowledge-based work.

In this paper, we examine and evaluate several specific types of information technology (knowledge repositories, expert locators, virtual collaboration, workflow management, and expert systems), including their strengths and weaknesses, used in knowledge management projects. After this overview, we provide a framework to analyze these IT applications in the context of:
1). where the knowledge resides (explicit and tacit knowledge), and
2). how the knowledge is being used (tactical and strategic use).

This will help us examine the role of information technology with regards to some specific aspects of knowledge management. We will draw on several examples of knowledge management applications across different industries to illustrate the framework.

Introduction

At the beginning of the new millenium there can be little doubt that knowledge itself, whatever it's different interpretations and meanings, is being perceived more and more as a critical resource within organizations and even within nations. Books continue to proliferate on the subject; new journals devoted to knowledge are planned and brought forth, as are scholarly articles, research reports and NGO studies. A search on Amazon's web site found over 4,800 books with the word 'knowledge' in their title. While ten years ago, there were no conferences anywhere planned on knowledge, conferences now abound throughout the world. Within large global organizations, knowledge projects are the norm, and several prominent firms have appointed knowledge or learning officers and executives to oversee the organization's knowledge-specific projects, strategies and operations. A survey by the Conference Board found that by 1999, 82% of companies were pursuing knowledge management initiatives, and a large percentage of the remaining 18% said they planned to pursue knowledge management in the future. [1]

Where did all these activities come from? Why is seemingly the whole world interested in a topic that had very few researchers only a short decade ago?

Several global or macro causes seem salient to us and they are worth mentioning if we are to better understand how this movement came about and what the role of technology within it indicates. Perhaps the most important issue is the growing global diffusion of technical knowledge and know-how which has had a two-fold effect. The first is that as the knowledge of how to perform technical tasks spreads globally, more and more of this knowledge-intensive manufacturing will take place in developing nations. As we write, India is now the leading global producer of software code and

Ireland has totally transformed its economy by focusing on high-technology manufacturing.

The second cause is based on the turn to services within firms. Since firms seek to rationalize their operations and find the most efficient and economical ways in which to operate, it is no surprise that more and more organizations in the developed world are either abandoning manufacturing as a result of being non-profitable or outsourcing their manufacturing to the developing countries. Subsequently, they turn to services as a source of wealth. IBM, for example, often perceived as a technology manufacturer, receives at least half its revenues (and even more of its profits) through providing services. This global trend towards services has been a very powerful force in focusing attention on knowledge, since knowledge is in essence what a service firm provides in one form or another. Insights, judgements, creativity, design, and innovation itself are all knowledge-like activities that organizations are more and more managing as profitable assets.

Another important macro-trend influencing knowledge management is the unexpected consequences of ubiquitous and universal information access. As computerization proliferates, and more people gain access to the Web, information itself becomes easier to identify, access and procure. All, or most, economic advantage that comes from information asymmetry such as monopolies or oligopolies are likely to rapidly diminish as search engines become more efficient, a greater number of institutions develop web sites, and the proliferation of small and cheap computers continues.

However as information costs drop, knowledge increases in value. As we will show, many forms of valuable knowledge cannot be digitized. For example, tacit knowledge is embedded in humans and is emergent within networks and communities. To freeze and digitize it may be valuable – but it changes knowledge into information (or, as we say in this paper, structured knowledge). Actual knowledge itself – whose outputs include judgement, insight, innovation, wit, style, discernment and other human dimensions, cannot be digitized and therefore its value increases. Clearly, workers who have proven knowledge within a field still command high earnings and are a firm's single largest expense – especially firms that are service based and knowledge intensive (which many traditional firms are trying to become). The want advertisements are still bursting with notices seeing to entice such workers, and executive recruiters are as busy as ever trying to find such folk. Clearly knowledge, as embodied in experts, still commands substantial and immediate attention within labor markets and its value has not at all been diminished with the ubiquity of information.

There are several forces working within organizations that are turning the attention of executives towards knowledge and knowledge projects. One of the strongest is the evident but elusive role of knowledge in explaining performance variation within large organizations. All geographically dispersed operations within an organization has access to the same official, centralized knowledge and has somewhat uniform incentives, technologies, norms, and policies. What then explains the great variety of performances in plants, retail sites, operating units, oil fields, etc.? Many firms have struggled with this issue only to eventually realize it was *local knowledge and practices* that was the decisive factor in positive performance. This knowledge is rarely if ever documented and tends to

stay local. Firms such as British Petroleum, Cargill, and Ford and Roche have all successfully tried to make the local knowledge of outstanding performers more universal within their operations.

Another strong motivation for knowledge projects is the extraordinary pressure being put on firms to be more productive and innovative. Globalization brings with it a more global division of labor that quite radically increases the number of entrants to an industry but also puts pressure on the industry's total output. More players, more products, and more consumers may bring greater aggregate wealth, but it also brings unheard of pressures on firms to both innovate new products and be more productive in doing so. Firms such as Intel, General Motors, and Bristol-Meyers Squibb have all approached these challenges using KM approaches that recognize how diverse forms of knowledge can be used and reused to bring about innovation. As far as productivity, several examples in the following text describe how knowledge and technology are aiming for increased efficiencies and productivity within organizations.

There is little doubt that information technology (IT) has been a central part of the knowledge management movement we have just described, often providing the infrastructure needed to transfer knowledge within and across organizations. However, what is less clear is the role that IT plays across different knowledge management activities, such as knowledge creation, capture, sharing, and access. Is IT more suited for certain knowledge management activities or for certain types of knowledge? What complicates this question even more is that the IT marketplace itself is very dynamic, with the emergence of the Internet and Web-based applications and the continued decline in the cost of computing and networking. In addition, IT vendors often have their own

conceptions of knowledge, equating it with information or even data, which further confuses the issues.

It has been argued "technology's most valuable role in knowledge management is extending the reach and enhancing the speed of knowledge transfer." [2] Information technology is indeed very useful in capturing, storing, and distributing structured and codified knowledge, therefore enabling other individuals in the organization to have access to it. However, IT plays a much more limited role in knowledge creation, which is very much a social process involving the exchange of hard-to-codify knowledge and personal experiences. [3,16] Also, IT, by itself, cannot create a knowledge-based environment that promotes knowledge use and sharing. For any technology to be optimized, it must be augmented by strategy, process, culture, and behavior that support knowledge sharing and knowledge-based work.

We next examine and evaluate several specific types of information technology (knowledge repositories, expert locators, virtual collaboration, workflow management, and expert systems), often used in knowledge management projects. After this overview, we provide a framework to analyze these IT applications in the context of:

1). where the knowledge resides, and

2). how the knowledge is being used.

The will help us answer the question posed earlier about the role of information technology with regards to some specific aspects of knowledge management. We will draw on several examples of IT applications across different industries to illustrate the framework.

Knowledge Repositories

One of the most popular uses of information and information technology in knowledge management is as a repository of structured, explicit knowledge usually in the form of documents. The typical objective of these repositories is to take knowledge that resides in documents and place it in a structured repository where it can be easily identified, captured, accessed, and retrieved by others within the organization. Usually, the source of this structured knowledge can be found both within and outside the organization. Examples of internal knowledge documents include research reports, product materials, regulatory reports, field trip reports, lab notebooks, and process manuals, while external knowledge documents may include reports on competitive intelligence and business partners.

Two specific types of knowledge management documents, which are often referred to in KM work, include *best practices* and *lessons learned* reports or descriptions. Best practices define an effective or presumed optimal way to perform a particular process or task that has been identified and selected either inside or outside the organization. Best practices are often stored electronically in repositories, and are used to support or guide users in performing a specific task. Lessons learned help decision makers by linking past results with the decisions that led to these results. This enables the organization to learn from past experiences, and helps ensure that the same mistakes will not be repeated in the future. These systems are frequently sold to organizations by consulting firms as a way to systemize an organization's "knowledge". The now classic phrase "If Hewlett-Packard knew what Hewlett-Packard knew, we would be five times more profitable", attributed to then Hewlett-Packard CEO Lew Platt, is often brought out

to rationalize these decisions (i.e. If these systems can better let employees "know" what their organization "knows", profits will be maximized). Of course, much depends here on what the word "knows" means in these contexts.

Obviously, one of the benefits of having a repository is to allow capture and access of knowledge from across the organization. Localness is no longer perceived as being an issue since it does not matter to the user where the physical documents reside. The surge of the *portal* phenomenon in recent years has led to an increased interest in repositories of knowledge. The enterprise-wide portal promises to aggregate all structured knowledge from different sources within an organization through a single point of access. By navigating the Web-based portal by clicking on links, the user should have access to disparate knowledge and information at their fingertips.

However, enterprise-wide portal applications have met with mixed success. One of the challenges has been retrieving the appropriate documents. Often as is the case with enterprise-wide portals, users are left frustrated searching through vast amounts of documents and not finding a specific piece of knowledge or information that will help them. Therefore, a lot of thought should go into the design of the repository, including the search-and-retrieval engine, and some approach to managing the meta-knowledge, or data and information that describes the various pieces of knowledge. It might be useful to design an on-line thesaurus, since users may be looking for knowledge using terms that might not have been anticipated earlier. Another criticism of enterprise-wide portals and repositories is that they are too broad in focus to attract groups of users across the organization. A more focused portal strategy, such as ones used in customer relationship

management, will allow the design of the portal and repositories to be more aligned with the requirements of the end users.

Also, we should state that while systems such as these have an obvious and immediate benefit in allowing users to identify, access, and retrieve key documents, there are several issues that emerge when these systems are executed that should be mentioned here. The most important one is that the end-users are often disappointed in what they receive. Since the documents were most likely written for a different situation, within a different context, and at a different time, then the resulting document is often less relevant than that which the user had wished. A second constraint is that a document can be understood as "frozen knowledge" not as a form of dynamic knowledge as the word is commonly used.[4] Frozen knowledge is one-way, not interactive (one can scarcely query it!) and has no emotional tone, as a conversation or discussion has.

Another potential disappointment usually occurs with the executive funders of these projects. There is the expectation of completion or closure regarding an organization's knowledge. In many instances, such projects are called knowledge exchanges or knowledge bases, and are proposed with the assumption that they will somehow encompass the organization's "total knowledge". Even limiting this assumption to structured knowledge renders it fatuous. It is no wonder that disappointment ensues.

Expert Locator

Whereas knowledge repositories are used to capture structured knowledge and information found in documents, expert locators are used to identify and presumably connect users to human experts within and outside the organization. This application

allows users to find experts in a particular knowledge area by searching through a taxonomy of bibliographies or profiles. The expert profile might contain data such as current jobs and responsibilities, previous jobs both within and outside the company, educational background, publications and honors, and any particular skills the person might have. As with a repository, the search engine should be linked to a thesaurus since users and designers of expert locator systems might use different terminology to classify expertise.

The expert locator applications can include an expert or skills inventory database, electronic yellow pages or directories, and project participation or the monitoring of a person's activity. More recent applications allow for a *dynamic* building of expert profiles and real-time connections to people and communities. For example, there are several such applications that extract key terms and phrases from email content and other documents and builds them into a profile. Since the emails and other documents are constantly analyzed, the profile is kept up-to-date. Users can send a request to find subject matter experts in a particular area, and the application then searches through the profiles to determine who has this expertise. Rather than exposing the requester to all information on all possible matches, the application sends an alert to those individuals who should be able to handle the request. Those experts can then choose to respond to the request.

There are several challenges with developing expertise location applications. First, there may be a large time commitment on the part of the expert to enter and update profiles in the system. Motivating employees to continuously update their profile may be difficult. Even more dynamic applications that key off of users' email or documents may

need to be reviewed or changed by the expert. Finally, the process of designating an "expert" in a certain knowledge domain is often met with political interference and obstacles within an organization.

While this application is particularly popular and obviously valuable, it too often runs into some organizational constraints when trying to operate effectively. A critical issue is just how available and valuable will an "expert" be to an individual's needs. Such a system assumes a constant and strong sense of employee altruism that is rarely the case in most organizations. Specifically, our own research has shown that there are several steps or stages that need to be negotiated before any knowledge can be effectively transferred between an expert and a questioner. [5] These stages can be summarized as:

a). Identification – finding actual individuals who can best help you.

b). Access – gaining time with such a person. Since time (especially the time of an expert) is under such serious limitations, often gaining an audience is problematic without some reciprocity. [6]

c). Engagement – this is the active listening and caring that an expert brings to your problem. As in access, it is very hard to assure or guarantee a positive response and yet meeting can be useless without some sort of engagement.

d). Safety - this is your sense of trust that the expert will keep your situation and position confidential. Research indicates that lack of trust in an expert's discretion is a major inhibitor to knowledge sharing. [7,8]

Virtual Collaboration

When we talk about knowledge in the organization, much of it is in tacit form residing and embedded in the minds of individuals and emergent within communities, rather than explicit in documents. It is often estimated that 70 percent of organizational knowledge is tacit.[9] Therefore, one of the major roles of information technology should be to connect people to each other, as well as support the collaboration and innovation that may take place among them. We often state that this "connectivity", in all its forms, is perhaps the best goal for IT in supporting knowledge work.

Traditionally, when we think of IT as a collaborative mechanism, we often think of tools supporting asynchronous transmission, such as email and groupware. Email has become a standard way of communicating text-based messages in an organization. Groupware is technology designed to support a group of individuals. This technology usually involves messaging capability, such as email, a discussion group to allow group members to post messages and have a discussion on a particular topic, and a bulletin board or repository to post notices or documents. Sometimes, a group of individuals, who are not part of the same group or department, want to communicate on a particular interest, goal, or practice and want to advance their knowledge. These "informal" communities are often referred to as *communities of practice*, and have become widespread in today's organizations.[10,11] Technology plays an important role in supporting these communities by providing a virtual meeting place, access to and management of documents, and support of online discussions. Communities can also exist with external business partners, and private exchanges or extranets make possible

services such as online auctions with suppliers or the co-design of products with customers.

Recently, synchronous virtual collaboration technologies, such as Web conferencing, instant messaging, and white-boarding, have become more prevalent in the workplace. The market for real-time collaboration technologies has penetrated only 5 percent of its potential market. This market achieved a 111 percent growth rate in 1999 to $6.2 billion, and high growth rates are expected to continue in the near future. [12] The market for Web conferencing alone is predicted to be $4.5 billion in 2003, with growth rates of over 70 percent in the near term. [13]

In our opinion, these technologies provide the potential for increased knowledge sharing and creation since they enable real-time, richer communication among individuals than traditional email. Web conferencing enables the synchronous sharing of text, audio, video, and documents with a group or team. This technology allows virtual meetings to take place, resulting in decreased meeting expenses and increased communication within the company. With the tragic events of Sept. 11, 2001, companies have indicated they will increase their use of virtual meetings through Web conferencing. Organizations are using Web conferencing for sales activities and product demonstrations, especially for business-to-business customers. Distance learning applications also rely heavily on web conferencing. Videoconferencing, often embedded in web conferencing systems, allows for real-time interactions between students and teacher, while documents can be shared and annotated in real-time during training. White-boarding technology allows for users to remotely share and edit documents and files at the same time.

Instant messaging allows users to send messages to each other simultaneously. Instant messaging is starting to be used by organizations as a way to provide assistance to customers. Web-enabled call centers are expected to grow at a compounded growth rate of over 20 percent through 2003. [14] This technology can reduce customer wait time, especially when compared to wait times associated with customer phone calls. Instant messaging can also help close sales in real time, since this service may only be available to customers who are currently purchasing a product or only be available to the most valuable customers. Another advantage of this technology is the ability to interact with several customers at once. [15] In the future, instant messaging software is expected to incorporate audio and possibly even video.

Synchronous technologies, such as Web conferencing and instant messaging, should not be thought of as a replacement for asynchronous technologies such as email, but rather as a complement. Most likely, there will be a convergence of technology features, such as Web conferencing applications incorporating email and repository features, for example. One of the main challenges with virtual collaboration, though, is to create a trusting environment to share knowledge. Without initial face-to-face interactions, it may be difficult to get employees to collaborate with people they do not know. Trust is usually established within an initial meeting and sustained by live encounters at periodic intervals. [16]

Workflow Management

Workflow management systems enable the tracking and management of task-based work processes through an online community of users. Generally, these systems

involve a series of steps or criteria needed to complete a specific task, identification of the people (or roles of the people) that need to complete a specific subtask, and a schedule to identify when the subtasks should be completed. The workflow process is usually graphically represented, and owners of a subtask are usually notified of their task responsibility via a message or email system. As users respond, the workflow map is updated to reflect the change in the process status. In essence, workflow systems manage the information and knowledge associated with processes and process flow in the organization. Work processes may require knowledge from many different sources, including both documents and people, and creating a workflow system provides access to the disparate knowledge from a single, electronic user interface.

A workflow system can reduce costs by acting as an online process manual, enabling inexperienced users to carry out complex tasks; save time searching for critical knowledge that may reside in different locations; ensure greater accuracy and verification of a process by ensuring all steps have been followed; and refer only "exception" cases to senior managers, so as to more effectively use their time.[17] Also, these systems often reduce the need to physically handle paperwork, since most information can be transferred electronically.

Today, work processes may also involve external partners, such as suppliers or customers. For example, a company working with a network of suppliers may develop a workflow system to manage and track their procurement for projects online. Or, customer workflow systems can be created to perform sales transactions or to enable online help. In this case, customer problems are more easily tracked and captured, which could then be used to help plan future customer offerings.

Most of the technological challenges have to do with integrating or consolidating back end systems, some of which may be legacy systems, associated with the work process. The key to the workflow system is to have seamless integration, so it appears to the end user that all of the information and knowledge comes from one location. XML and middleware are often used in the integration process. Finally, much of the difficult work associated with workflow management systems is upfront, or identifying and designing the steps in the process, the knowledge and information requirements, and the people who own the subtasks. Therefore, careful attention must be paid to planning the workflow system, in order for implementation to succeed.

Expert Systems

A final category of information technology that can be used with knowledge management applications is expert systems. Sometimes going under the more generic name "artificial intelligence", technologies such as expert systems, case-based reasoning, and neural networks try to focus on and capture a very specific and narrow domain of knowledge. Expert systems are usually structured as a set of rules, extrapolated by structured interview methods usually called knowledge engineering, to enable the knowledge of one or a few experts to be used by a broader set of employees.

Case-based reasoning systems require someone to input a series of "cases" or narratives, which represent embedded knowledge about a specific knowledge situation. These cases each include problem characteristics and problem solutions. Companies have applied case-based reasoning systems to such processes as product design, scheduling, customer service, and legal reasoning.

A neural network is a statistically oriented tool that excels at using data to classify cases into one category or another. One unique characteristic of neural networks is that they "learn", or their classifications become more accurate with more cases. [18] The neural network approach is used to take vast amounts of data, look for patterns, and then turn this into knowledge. This is often referred to as "data mining".

Although offering much potential, expert systems have frequently been over-hyped and then under-performed in terms of what they were expected to do. [19] One problem with extracting knowledge from a few experts into rules and cases is that this is a very long, tedious process, and that by the end of the process, the rules or cases themselves might have changed. Often, rules or cases become obsolete and need constant updating. The knowledge domain itself has to be narrowly focused and well designed. Experts themselves might be unwilling to share their expertise with the rest of the organization since this expertise is the source of their power and influence within the organization. Perhaps the biggest problem is that most valuable knowledge embodied in people is undocumented and only partially understood by the people themselves. Subsequently, this knowledge cannot be codified or turned into an algorithm. [20]

A major problem with neural networks is that it is difficult to explain how and why the system came up with a particular solution. Therefore, interpretation of the solution by the decision maker becomes problematic. These expert systems have been implemented with some success in certain narrowly focused knowledge projects. However, they have not led to an organization-wide movement towards knowledge management for the reasons just described.

Knowledge Management Application Framework

In this section, we provide a framework to analyze knowledge management applications. This framework will help us understand the role of information technology with regards to knowledge management. We will draw on several examples of knowledge management applications in the literature to illustrate the framework. It is important to note that the five categories of information technology just described are not mutually exclusive. For example, a virtual collaboration system, such as a web conferencing, can incorporate a knowledge repository. Also, any particular KM application can consist of multiple information technologies. Therefore, it is best to look at instances of KM applications, and the role of IT in these applications.

We provide a framework (Figure 1) to analyze KM applications in the context of:

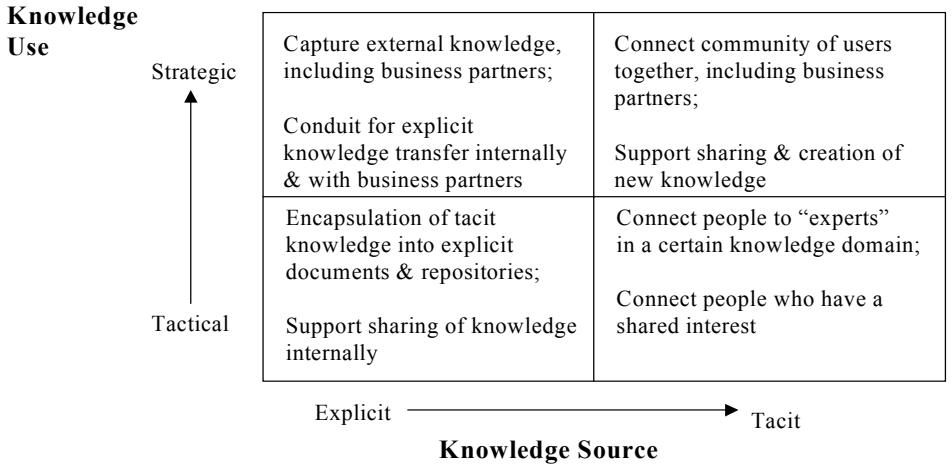
1). where the knowledge resides, or knowledge source; and

2). how the knowledge is being used, or knowledge use.

Knowledge Source: The knowledge source dimension describes where the knowledge used in the application currently resides. We distinguish between explicit and tacit knowledge. Explicit knowledge are resources that are codified and transferable in a formal, systemic language.[21] It is knowledge that can be found in contracts, manuals, databases, or embedded in documents. Tacit knowledge are those resources that have a personal quality making it difficult to formalize and communicate.[21] Tacit knowledge can reside in individuals, such as employee expertise and know-how as a result of years of on-the-job-experience, as well as in organizations, such as company culture and communities.

Knowledge Use: The knowledge use dimension describes how the KM application is being used. Tactical use indicates an operational or process focus, where the emphasis is on cost savings and efficiency. There is more of a narrow scope associated with tactical use, and usually this does not lead to sustainable competitive advantage for the organization. Strategic use, meanwhile, has an enterprise-wide impact leading to significant bottom-line results. Usually, the KM project transforms the organization, either in terms of its product and service offerings and how it develops them, or how it deals with its environment including external business partners. Strategic use usually leads to sustainable competitive for the organization. In other words, it would be difficult for its competitors to imitate the KM system.

Figure 1: Role of IT in Knowledge Management Application Framework



It is important to note that the two dimensions, knowledge source and knowledge use, are continuous dimensions, not discrete dimensions. In other words, there are varying degrees of tacitness and varying degrees of strategic use of knowledge. It is not an "either-or" proposition for either dimension. Also, any particular knowledge management application can have multiple uses and multiple knowledge sources. It is important to keep this in mind as we illustrate the four quadrants of the framework with examples from practice. Even though we describe an example of a KM application in the quadrant of the model we feel it is most situated, that KM application could perhaps fit in more than one quadrant.

Also, we would argue that each quadrant represents value to an organization. KM applications that leverage tacit knowledge for strategic use (upper-right quadrant) might provide the most potential value to an organization since they are the most difficult for other companies to imitate. However, they are also probably the most difficult to implement because of all the organizational and social challenges that exist during implementation. Finally, KM applications tend to be dynamic. For example, they might be implemented in a particular area of the organization, and once tactical benefits are achieved, might be extended to play a larger, strategic role within the organization.

KM Applications in Practice

We next describe real-world knowledge management applications from the literature in the context of this framework (see references for a more comprehensive description of each company's knowledge management use) and the role of information technology in each quadrant of the framework.

Explicit Knowledge for Tactical Use

The lower-left quadrant involves those KM applications that utilize explicit knowledge for tactical use. The role of information technology in this context is to encapsulate tacit knowledge into explicit documents and repositories that can be leveraged by others in the organization. IT also helps with explicit knowledge transfer within the organization. The following three companies, Monsanto, Chevron, and Foundation Health Systems, have successfully used knowledge management to capture and leverage knowledge in explicit form in repositories, resulting in improved operations.

Monsanto, a provider of agricultural and pharmaceutical materials, used knowledge management to improve operational efficiency across their businesses and to serve customers better.[22,23] At the center of their efforts was a knowledge management architecture that brought together data warehouses of internal, external, qualitative and quantitative categories of information. The results revealed that the KM system removed geographical and organizational separation. Employees were better informed and more productive since they could focus on the more value-added aspects of their jobs and not have to spend too much time searching for information. The final result was that key information and knowledge was made available to decision makers across Monsanto's many business units.

Chevron, an integrated energy and chemical company, recently experienced operational benefits by implementing a best practice repository.[23,24] A database was designed to promote the sharing of practices, know how, and experiences. Two best practice teams saved over $170 million by sharing information among geographically distributed groups.

Foundation Health Systems, a large managed healthcare organization, used knowledge management to increase the flow of information across the organization through workflow systems.[25] They built a fourth generation medical management system that allowed practitioners to access a single repository for knowledge such as a patient's history and physician protocols. Best practice protocols allowed the admitting physician to put a patient on a particular protocol, and helped remove unintended variances that may have been occurred because of the lack of standardized processes. Customer service also improved since the customer could access all information critical to his or her healthcare in one place.

Explicit Knowledge for Strategic Use

The upper-left quadrant involves those KM applications that utilize explicit knowledge for strategic use. The difference here is that the KM application leads to enterprise-wide impacts, usually involving business partners such as customers and suppliers, as opposed to more local impacts when used tactically. The role of information technology in this context is to not only encapsulate tacit knowledge into explicit documents and repositories that can be leverage by the entire organization, but also to act as a conduit of explicit knowledge transfer with business partners.

Sequent Computer Systems, a provider of customized IT systems for commercial firms, used knowledge management systems to capture, organize, and reuse much of the knowledge generated in projects with their customers.[26,27] This improved customer value and service, especially with the more complex projects. The results imply a strong correlation between improved knowledge management and improved business

performance. Business results included record revenue, increase in project selling prices, reduced deliver time for solutions, and perhaps most importantly, an increase in customer value perception in Sequent products, in terms of both loyalty and selling price.

Broaderbund Software, an interactive software developer, viewed knowledge management as a mechanism for customer service improvement, problem resolution, and product development.[28] Broaderbund developed a case-based reasoning (CBR) system containing roughly 8,000 cases and sales information on 300 products. Call center representatives used the CBR system to help with customer problems. Customers also had access to an external CBR system, which could be used by them to help solve their own problems directly. The CBR system was used strategically in the sense that knowledge from the CBR was used by Broaderbund's new product development group to help develop new products and product updates.

Tacit Knowledge for Tactical Use

The lower-right quadrant involves those KM applications that utilize tacit knowledge for tactical use. So far, we have given examples of companies leveraging explicit knowledge, such as best practices, product cases, and customer information, captured in repositories and databases. Increasingly, however, KM applications are leveraging tacit knowledge of employees, communities, and external business partners, by providing employees with direct connections to the right people at the right time. The role of information technology in this context is to connect people to "experts" in a certain knowledge domain, or to connect people to others who share a similar passion or

interest in a particular area. The following are examples of companies who use KM applications to connect people to other people directly and in real-time.

Chemical distributor Van Waters & Rogers used web conferencing technology to host virtual meetings, such as strategy meetings and training sessions.[12] These meetings involved technologies such as slide shows, participation polls, and white boards. Van Waters & Rogers used web conferencing to achieve two main operational objectives: decrease meeting expenses and increase communication within the company.

The retailer Lands' End used instant messaging to improve their customer service.[29] They found that customers would shop more frequently online if the customers could get real-time answers to their questions. Lands' End also used instant messaging to get feedback from their customers. Besides traditional mediums for customer feedback, such as postal mail, telephone, and now email, instant messaging provided a very quick and easy way for online customers to share their thoughts on Lands' End products and services.

Companies can also use IT based systems to find potential business partners. For example, Payload Systems used the ManufacturingQuote system to manage its procurement with suppliers.[30] ManufacturingQuote puts buyers and sellers of manufacturing services together. Payload Systems would upload a description of its project, including the desired services, and vendors would bid on the project.
The system was especially useful for very specialized projects, where it was difficult to find suppliers offering the requested services or parts.

Finally, government agencies, such as the Army and Navy, have launched distance learning programs to save costs and sto learn quickly.[31] These programs used

Web-based, satellite, and videoconferencing technologies to deliver training to employees in remote locations. Also, the costs associated with distance learning are usually lower than the costs associated with traditional classroom training.

Tacit Knowledge for Strategic Use

So far, we have given examples of companies leveraging tacit knowledge in applications such as virtual conferencing and distance learning for tactical use. Tactical benefits include cost savings, improved customer service, and access to remote information and knowledge for better decision making. Next, we discuss KM applications that leverage tacit knowledge for strategic use (upper-right quadrant). The role of information technology in this context is to connect communities of users together. Often these communities involve external business partners, and have an impact on organizational strategy (e.g. new product development). Another role of IT in this quadrant is to support the sharing and creation of new knowledge and information.

At UBS Warburg, traders have used instant messaging to spread critical information quickly, both internally and with clients.[29] In 2001, roughly 1,500 clients and 14,000 UBS Warburg employees used the system. Employees formed topic-based groups to communicate on a particular subject. Perhaps most importantly, the instant messaging system has allowed UBS Warburg to improve its client relationships by getting *customized* knowledge and information to the customer more quickly than their competitors, thus providing a competitive advantage for the company. Initially, the system was designed for foreign-exchange traders, but has now spread across the entire

organization to include human resources, IT, networking, and telecommunication departments.

Oracle launched the Oracle Technology Network (OTN) Xchange system in the Fall of 2000 as a service to the developer community. [32] The OTN Xchange provided an online marketplace where developers could interact with each other through the buying, selling, and auctioning of technical services. This helped developers, who are members of the marketplace, gain access to programming expertise. The Oracle network also supported collaborative work by enabling users to manage development projects online. Oracle benefited strategically from the fast development of Oracle-based software and the resulting increase in license revenue.

Finally, Nippon Roche, a pharmaceutical division of the Swiss healthcare company Roche Group, improved their bottom-line revenue performance by effectively leveraging their tacit knowledge. [33] The company launched the Super Skill Transfer (SST) program in 1998, which focused on integrating the knowledge of its medical representatives developed with their key customers, medical doctors. The company also selected 24 of its best performers, and through metaphors and stories, the tacit knowledge of these performers could be shared with the rest of the company. Nippon Roche also used satellite TV as a way to share both tacit and explicit knowledge throughout the organization. The SST program has gone beyond providing tactical benefits within the sales function to now contributing to innovation throughout Nippon Roche.

In summary, we have described the role of information technology in knowledge management applications, based on the type of knowledge used (explicit and tacit) and how it is being used (tactical versus strategic). We posed the question earlier, "What is

the role of IT in KM applications?" As illustrated, IT has many roles in KM applications, including encapsulating knowledge in a structured form, acting as a conduit for knowledge exchange, connecting people to other people, and supporting the innovation process. What is critical for organizations to understand is how to extract the most value from their knowledge assets. Certainly, IT is a major piece of this puzzle, but as we emphasized throughout the paper, what is important to recognize is that organizational and social processes and norms will hugely impact the role of IT. For example, it might be the case that virtual meetings are highly productive only after the participants are familiar with one another. In any event, the social and organizational context must be clearly understood to successfully implement KM applications.

Conclusion

Recognition is growing amongst executives, economists, consultants, and journalists that knowledge is a source of wealth that can be even greater than the traditional forms of wealth – land, labor, and capital. While we do not have all the pieces in place to prove how all this works, organizations still need to move ahead in trying to both optimize the knowledge they currently have, and plan as best they can to acquire the knowledge they will need. The demand for both social and information technologies will become even stronger as organizations take a strong "turn towards knowledge" in the new millennium.

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About the Authors

Laurence Prusak

Laurence Prusak, a Managing Principal with IBM Global Services, is the founder and Executive Director of the Institute for Knowledge Management (IKM), a global consortium of member organizations engaged in advancing the practice of knowledge management through action research. Larry has extensive consulting experience, within the U.S. and internationally, in helping firms leverage and optimize their information and knowledge resources. He has also consulted with many U.S. and overseas government agencies and international organizations (NGO's). Prior to joining IBM, Larry was a Principal and founder of Ernst & Young's Center for Business Innovation, specializing in issues of corporate knowledge management. While there, he was responsible for helping to build a consulting practice centered on organizations managing their knowledge resources.

A respected authority in his field, Larry has lectured and been published widely. His new book (co-authored with Tom Davenport): *The Career of Ideas* will be published by Harvard Business School Press in 2002. His most recent book (co-authored with Don Cohen), *In Good Company: How Social Capital Makes Organizations Work* (Harvard Business School Press, 2001) was listed as one of 2001 Best Business Books awarded by Harvard Business School. He has also co-authored another two books with Tom Davenport: *Information Ecology* (Oxford University Press, 1997), and *Working Knowledge* (Harvard Business School Press, 1998).

Salvatore Parise

Dr. Salvatore Parise is a Research Consultant in the Institute for Knowledge Management at IBM where he consults and performs applied research with organizations on issues involving strategic alliances, knowledge-based strategy and organizational design. He completed his Doctorate in Business Administration degree in 2000 from Boston University's School of Management, working in the area of strategic alliances in the computer industry. His current research interests include multilateral alliance structures, business strategy development, organizational learning, and alignment between business strategy and alliance strategy. His recent publications include: "Knowledge Resource Exchange in Strategic Alliances" with John Henderson (*IBM Systems Journal*, 40(4), 2001), "Partnerships for Knowledge Creation" with Laurence Prusak (World Bank Conference on Economic Development, 2002), and "Cooperating with Life-like Interface Agents" with Sara Kiesler, Lee Sproul, and Keith Waters (*Computers in Human Behavior*, 15(2), 1999).