A previous essay in this department\(^1\) described how organizations are finding themselves in catch-up mode. They’re losing their ability to conduct business as their workforce ages and critical knowledge walks out the door. A number of social, economic, technological, and scientific trends have led to the emergence of communities of practice centered on the notion of the knowledge-based organization. However, the scientific foundation (knowledge elicitation methodology) and the commercial growth of knowledge management (KM) have largely developed in parallel—that is, independently. So, the creation of human-centered systems faces lingering challenges. For each challenge, we ask, is this a matter of building intelligent technologies or of using technology intelligently?

**Background**

As the expert-systems field morphed into what’s now broadly called *intelligent systems*, it became clear that we could preserve corporate knowledge by using the knowledge-elicitation methods that had been used to create knowledge bases and inference engines.\(^2\) For all their limitations and brittleness, expert systems had pointed to the idea that organizations might create knowledge repositories.\(^3\) We could then use the knowledge bases, including corporate “lessons learned,” in training and corporate problem solving.\(^4\)

Norman Kamilkow, editor in chief of *Learning Officer Magazine*, seems to agree. He said, “There is a growing role for a chief learning officer type within enterprise-level companies. … There is a need to have somebody focused on how to keep the skills of the corporation’s work force at a high level.”\(^5\)

In the KM process, company management establishes a program whereby experts who possess valuable knowledge collaborate with a knowledge engineer. Working together, they elicit the expert’s wisdom for inclusion in the organization’s knowledge base. In extreme cases, such as when a senior expert with specialized knowledge is soon to retire, the organization might retain or bring back the individual as a consultant.\(^3\)

The KM literature on business management and the trade press on KM suggest that a wave of enthusiasm about KM hit in the 1990s but was followed by some disappointment.\(^1\) The disappointment might have stemmed largely from limited KM software solutions, overzealous software sales personnel, or merely poor project implementations. For example, of over 220 KM implementations in 2000, at least half were “deeply suboptimized.”\(^6\)

Certainly, issues of lack of trust and perceived effectiveness were and are in play.\(^7\) However, at least some disappointment could certainly be due to failure to properly embed these KM software systems in the human activities and work processes they were intended to support—that is, lack of human-centering. Whatever the reasons were, various trends and forces have encouraged a renewed interest in KM.

**Workforce issues**

Workforce mobility and its implications for the transfer of expertise have made KM a hot topic ever since this HCC department last discussed it.\(^1\) For example, in even the most highly technical military jobs, the tradition of regular change of duty assignment requires considerable relearning. Just when a weather forecaster achieves journeyman-level skill at one locale, the Navy transfers him or her to some other climate.\(^8,9\)
Thus, there has been considerable discussion of the theory of organizational knowledge and KM,\textsuperscript{10–12} and the topic is familiar to the pages of \textit{IEEE Intelligent Systems}.\textsuperscript{13} Researchers are interested in how social factors and organizational culture come into play in determining whether KM is successful and whether the organization shares knowledge effectively.\textsuperscript{14}

Recent reports on the aging workforce have identified the upcoming retirement of baby boomers as the cause of an expected brain drain, in particular in specialized knowledge areas that have been unable to refresh their knowledge-worker base with recent graduates.\textsuperscript{15,16} For instance, a NASA study revealed that the average number of years of service for all occupation groups at NASA has been increasing since 1995, partly because the most recent science and engineering graduates are taking jobs outside government and partly because of years of government downsizing and hiring freezes.\textsuperscript{17} Most of NASA’s employees today are 40 to 60 years old, and less than 5 percent of NASA’s scientists and engineers are under 30. Currently, NASA has a number of programs of knowledge acquisition and KM, which includes the use of case-based-reasoning methods to form the architecture for a knowledge repository intended to help project managers find solutions to design, scheduling, and other problems.\textsuperscript{7,18}

Another example comes from the US electric-utilities industry, which employs some 400,000 people in the US.\textsuperscript{19} About half will be eligible to retire in the next five years.\textsuperscript{20} A survey of managers representing 21 electric utilities found that 92 percent believed that loss of expertise would pose a problem within the next five years. But only 30 percent indicated that a planning effort was in place to retain knowledge.\textsuperscript{14} Dale Klein, chairman of the US Nuclear Regulatory Commission, has said, “I have doubts about our ability to muster the workforce needed. … Where are we going to get the educated and skilled workers? … To a large extent, the knowledge reposes in the minds of older workers. … How do we transfer the knowledge to their replacements?”\textsuperscript{21}

People have set up a number of commercial enterprises to provide services that address this question.

### KM as a commercial enterprise

A Web search today shows considerable interest in KM activities and issues at international levels, reflecting the impact of global economic competition. KM is the topic of frequent meetings and Web forums (global brainstorming “Webjams”), hosted by institutes and government-industry partnerships. Numerous blogs and commercial Web sites offer a host of software products aimed at supporting KM in organizations. Web sites offer such things as “complete integrated design environments,” “principles for KM success,” “KM toolboxes,” and “knowledge portals.” Commercial e-magazines and monthly letters by authorities on “knowledge capital” give the impression that everyone sees value in retaining critical expert knowledge.

As a field, KM is undergoing refinement by subspecialization. The categories include knowledge capture, organizational learning, knowledge discovery, knowledge sharing, and knowledge application. Each of these is mated to a host of software systems, tools, and approaches ranging from more or less traditional management information systems to state-of-the-art Web-based virtual-community technologies and electronic knowledge networks.\textsuperscript{3} Some providers focus on eliciting experts’ knowledge; others focus on developing organizational staff to take on the knowledge-capture process.

### KM challenges

So, many are arguing that KM should be integral to an organization’s operational infrastructure and culture. This presents challenges for the science underlying KM.

#### Challenge 1: Finding the knowledge

The differential-access hypothesis, from the early days of expert-systems knowledge acquisition, stated that different knowl-
Knowledge-intensive organizations rely on decision makers to produce mission-critical decisions on the basis of inputs from multiple domains. The decision maker needs an understanding of many specific subdomains that influence decision making, coupled with the experience that enables quick, decisive action based on such information.

Is this an issue regarding intelligent technology or the intelligent use of technology? We think both. One of the many kinds of tools being used for KM is “expert locator” systems, which help people find experts who can consult on particular topics. Another type of tool uses a thesaurus of concepts and relations, developed by experts, as a searchable ontology linked to a document repository. Searching is, in a sense, locating expertise. Another type of locator is based on a database search (keywords descriptive of jobs) to find frames that describe individuals. Knowledge locators and people locators strike us as a first step. Frames about people can yield a list of people’s specializations, or a search on specializations can yield a list of people’s names, but this is only a first approximation to locating critical expertise. Better are the various special services that help locate particular domain experts (such as vacation planners and political consultants) to enlist their services. Yet this too is only an initial step.

We might benefit from protocols and social software that support sociometry, which could leverage recent advances in social-network analysis. We’ve known for some time that sociometric methods can help determine where expertise resides in an organization. A sociogram can be based on observations of people’s interaction patterns, communication patterns, and workflows. Individuals in an organization can be interviewed and asked, for example, “If you have a problem of type x, whom would you go to for advice?” They might be asked to sort cards bearing domain practitioners’ names into piles according to one or another skill dimension or knowledge category. We can think of a sociogram as a form of social-network analysis that identifies experts by revealing the organization’s knowledge network (that is, who talks to whom, how often, and about what).

Once you know where the knowledge is, you have to get it.

**Challenge 2: Eliciting the knowledge**

Organizations view seriously a number of quick-fix solutions. Some organizations advocate just-in-time training, even though the literature on expertise (and especially demonstrations of the role of deliberate practice) suggests clearly that just-in-time training is a recipe for just-in-time failure. Many organizations seek software that claims to capture knowledge as it’s created. The software might scan email, generate from it a repository of assertions to be posted on a Semantic Web server, and then generate computable ontologies and perform inferences.

In our experience, some organizations use weak methods for knowledge capture.

**Intelligent systems that merge the process of knowledge elicitation with the practitioners’ ongoing work must make the work easier, not harder.**

Typically, Human Resources personnel might grab the soon-to-retire expert, cloister him or her in a room, turn on a video camera, and ask, “Tell me everything you know.” After 60 minutes, they label the videotape and put it on a shelf to collect dust. Knowledge might be on the tape, but it’s neither usable nor useful. This seems like something of a caricature, but we’ve witnessed it more than once.

Less extreme are approaches that rely on various forms of structured interviewing, many of which are the essence of the practices of commercial companies that provide KM services.

So, is this a challenge for intelligent technology or for the intelligent use of existing technology? We think both. Reflecting the parallelism of scientific versus commercial KM, which we referred to earlier, knowledge providers can tap into the scientific foundations of knowledge elicitation and cognitive task analysis. We know that creating meaningful diagrams, in a process called Concept Mapping, is highly efficient at scaffolding experts in eliciting their domain knowledge. We also know that methods such as the Critical Decision Method (CDM) effectively elicit knowledge about processes, procedures, and reasoning strategies. Software for eliciting knowledge through Concept Mapping is growing in use, and the protocols for the CDM, including data collection forms, have been well specified.

Clearly, one limitation is that knowledge elicitation requires the active participation of a domain practitioner, who must forego his or her typical job obligations. These knowledge-capture initiatives “often fail because they make it harder, not easier, for people to do their jobs.” One idea is to forge intelligent systems that merge the process of knowledge elicitation with the practitioners’ ongoing work in such a way as to make their jobs easier, not harder. This has been called the “tough nut” problem, for good reason: Envisioning how such technologies would work is difficult. A software system for supporting physicians in the prescription-ordering process seems, on first look, like a good example. It requires the physician to provide an explanation or rationale whenever an order deviates from the one generated by the computer (via a knowledge base and inference engine). However, such systems can be considered intrusive. Indeed, administrators removed a computerized system for physician order entry from the Cedars-Sinai Health System in Los Angeles after nearly unanimous protest from the physicians. The tough-nut problem remains tough. Nevertheless, once you’ve collected the knowledge, you must do something with it.

**Challenge 3: Mentoring**

A tradition in some organizations is mentoring, especially for new hires (apprentices). On the other hand, some believe that mentoring can be a waste of resources. In yet other cases, where knowledge organizations have entered the catch-up mode, there’s a renewed recognition of the need to support mentoring processes. Increasing complexity, pace of change, pace of decision making, and worker mobility—all entail fewer opportunities for mentoring. Because of these trends, national leaders are formulating policies to support research and development in an educational infrastructure capable of producing the next
generation of the science and technology workforce. Even if such initiatives succeed, the results might be too distant to help solve the immediate workforce issues.

Is this a challenge for intelligent technologies or for the intelligent use of technology? It’s primarily the latter, but it’s also a challenge for work analysis, at least for the near future.

With regard to the challenge of intelligent use of technology, the methodology of software-supported knowledge elicitation, described earlier, is fairly well understood. There’s a missed opportunity here in that knowledge elicitation is typically regarded as a process in which elicitation is the sole activity. However, an organization’s apprentices could be participant-observers when the expert’s knowledge is being elicited. Also, such methods as “teachback” interviewing and question-asking (in which novices ask experts questions) have some use as an instructional method. If it’s true that knowledge elicitation takes experts away from their jobs, we could at least double the return on investment by merging elicitation with mentoring. This idea resembles what Josianne Basque and her colleagues did by having experts collaborate with trainees in creating knowledge models, using a concept-mapping approach, with more than 150 experts and 150 novices at Hydro-Québec.

Regarding the challenge for cognitive work analysis, although the literature on expertise studies is informative on what makes an expert teacher, it doesn’t deal with what makes a good mentor in the context of work (as opposed to the context of sports coaching, which has been extensively studied). To help conceptualize a system for mentoring employees along the continuum of expertise, one of us (Robert Hoffman) invoked the middle ages’ tradition of craft guilds. A master was any practitioner who was “qualified” to teach, meaning he or she embodied the special qualities of a good mentor. So, even a journeyman could be qualified as a master. There’s an unresolved need for robust, generalizable methods for identifying individuals having the most experience as a mentor and then conducting cognitive task analysis to reveal the mentors’ reasoning strategies, especially as they deal with challenging mentoring situations.

A second step would be to apply the research findings to accelerate the achievement of expertise. Experienced workers often feel motivated to pass along their “tough case” knowledge. However, the bureaucratic habit of expecting that mentoring will succeed can be the culprit when workers are left not knowing how to proceed or even that their tough-case knowledge is critical and highly informative to apprentices. We must refine our understanding of how mentoring activities can occur within the context in which the job tasks themselves must be conducted.

**Challenge 4: Costing**

None of the challenges we’ve mentioned can be solved quickly through “accredited training” or “manpower” procedures. We sense a lingering belief that knowledge-retention issues can be solved through normal training, better or newer computers and software, traditional workforce planning, and benefits and retirement packages. Many people possess unique, important, undocumented knowledge, even knowledge that might be captured using simple, routine administrative methods. This leads to the mind set that a little effort spread over many people will manage the risk. Historically this has worked because turnover was slow and the pace of technical change was manageable.

This is no longer the case in many areas of the private sector, such as the utilities. “In order to justify the time and money spent on an embedded-knowledge system, and to assess how well it’s working, an organization needs to have a measurement-oriented culture.” But what to measure? Some organizations in the electric-utility business are beginning to conduct “knowledge loss risk assessment.” This is a matter of intangible-asset valuation, which is difficult and can cloud the issues. We’re perplexed to find organizations in a catch-up mode, seeking easy fixes to what are still outstanding problems for an empirical science and methodology of KM. Although we lack good solutions to the tough-nut problem, as long as an organization is at risk because of loss of expertise, any effort to capture and preserve expertise is bound to have some long-term value. Nonetheless, we’re continually challenged to justify and calculate the short-versus long-term costs, benefits, and risks of doing (and not doing) knowledge capture.

As long as an organization is at risk because of loss of expertise, any effort to capture and preserve expertise is bound to have some long-term value.

**References**


