KNOWLEDGE MANAGEMENT IN RESEARCH AND DEVELOPMENT

A study of knowledge management practices in 19 leading companies yields a model for knowledge flow in the R&D process, aspects of KM unique to R&D, and a catalog of "better practices" that R&D leaders are putting to work.

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OVERVIEW: *Some R&D organizations have derived significant value from embracing knowledge management (KM) principles in order to promote the flow of both resident knowledge and external information. R&D's innovation charter demands a focus different from that of other functions, specifically, to nurture open access to people's extensive tacit knowledge—that which is "in and between minds." Your company's culture and structure will be the critical factors enabling knowledge flow, with choice of IT tools of secondary importance. From the many initiatives used by leading companies, there are at least six to choose so that you: 1) instill goals/strategies, 2) access tacit knowledge, 3) provide search tools, 4) promote creativity, 5) capture new learning, and 6) build a supportive culture. This last, most important, initiative—culture change—will take time and involve the entire business. A sustained commitment to the program is thus required. The results will be "worth the wait" in gold.*

In a turbulent and rapidly changing world, every organization faces the challenge of how to best manage its knowledge assets to generate value for the marketplace and obtain competitive advantage. Such advantage derives from special capabilities that are rare, valuable, nonsubstitutable, and costly to imitate (*1*). Historically, the focus was on capabilities involving tangible assets; now, knowledge is widely recognized as the source for competitive advantage, with the tangible assets representing the physical manifestation of but a fraction of this knowledge (*2,3*). As companies scramble to develop strategies for more proactively and strategically managing their knowledge, the field of KM receives increasing attention from trade organizations and academic journals.

This special report is the result of work by Industrial Research Institute member company representatives to better understand KM and specifically its application to Research and Development (see "How the Study Was Conducted," p. 30). Although many of the underlying assumptions of KM are not new, the formal study and application of KM in R&D organizations is a relatively young discipline. The goal of the study was threefold:

- Identify a model for knowledge flow in the R&D process that could be a visual point of contact for discussions around the key issues R&D managers face and the ways to manage knowledge flow.
- Highlight aspects of KM that are unique or especially important to the process of R&D.
- Catalog "better practices" that R&D managers use to facilitate knowledge flow and the knowledge creation process.

The findings from the research are reported in three Parts:

- Part I describes the flow of knowledge in R&D, develops a model that emphasizes some of the unique KM opportunities and requirements intrinsic to R&D, and shares high-level findings and conclusions.
- Part II details three specific enablers of culture, infrastructure and information technology (IT), summarizes specific KM application experiences related to these enablers, and identifies particular facilitators and inhibitors that affect KM performance.
- Part III suggests a holistic approach to implement KM in R&D. Six imperatives are presented with a recommendation that each be addressed for greater initial effectiveness and business impact.

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I—Knowledge Flow and Facilitating Practices *(C. C. Chappelow, F. M. Ross Armbrecht, Jr., and S. R. Postle)*

In this Part, we differentiate between Knowledge Management and knowledge flow in R&D. We discuss the nature of the flow of knowledge in terms of a model that emphasizes some of the unique KM opportunities and requirements intrinsic to R&D. We then share key findings from the research and conclude with our own learning from this work. To provide an appropriate context, it is necessary to first discuss our conception of the terms "Knowledge" and "Knowledge Management".

Knowledge and Its Management

Purists consider "knowledge" to be that which is *within and between the minds* of individuals and is tacitly possessed. Knowledge has the capability to add value to the organization (or individual). After knowledge has been explicitly captured (i.e., documented), the purist considers it to be a form of data or information (*4*). Data are better viewed as a "set of discrete, objective facts about events." Information is "data that makes a difference"; that is, it has a message that informs the recipient of potential value (*5*). This documented material—data

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and information—and knowledge are all vital to the R&D process.

In the course of our investigation, we came to understand that "managing" knowledge is not literally possible and, from an R&D perspective, we are really interested in facilitating *knowledge flow*. The difference between "managing knowledge" and "facilitating knowledge flow" can be illustrated by analogy to the flow of a river. Managing knowledge, in its most-commonly-practiced technocentric form, can be compared to the building of dams, embankments, locks, and weirs that regulate, direct and filter the course of a river. Facilitating knowledge flow, in this context, is more akin to ensuring that existing river banks are not washed away, that fallen trees are cleared so tributaries may flow unhindered to join the main course, and that, if the river overflows its banks, skilled farm workers are at hand to exploit the newly-deposited rich alluvial deposits (*6*).

Thus, when we discuss KM in this report, we are really talking about a knowledge flow process that reaches well beyond having excellent data/information storage and retrieval to embrace retrieval, creation, capture, use, and reuse of knowledge *and* information for innovation. A central focus for R&D, innovation is the successful exploitation of ideas to create a new, useful offering of product or service. An individual or a development team initiates the process by creatively connecting insight or foresight into the needs of the market with the potential capability to deliver a suitable offering. But knowledge *sharing* is a critical catalyst for creativity and subsequent innovation because it provides a means by which innovative ideas can be captured, shared or tested. This leverages the communal knowledge and leads to new and improved ideas. The "sharing" may be face-to-face, across distance with electronic technology, or across time with access to information archived by others. Promoting this knowledge flow in a way that stimulates the knowledge creation process is a major pursuit for R&D managers.

Knowledge Flow Models

Our early discussions of KM and knowledge flow were difficult and confusing because each person was envisioning a different concept. Consequently, to create a basis for dialogue around knowledge flow in the R&D process, we developed a visual model. Our main use for the model has been as a "boundary object." It facilitates dialogue about the issues and the key practices that R&D managers have in place, or would like to have, to enhance knowledge flow in innovation. Although we recognized the model was a simplification, only later did we realize how valuable its simplicity was, for it stimulated almost

How the Study Was Conducted

This research was conducted by the KM Subcommittee of the Research on Research Committee of the Industrial Research Institute. The Knowledge Flow framework (Figure 1) was used in group sessions or by questionnaire with R&D leaders from the IRI membership to elicit the issues most important to them. Issues were prioritized on the basis of potential impact on the R&D process. A survey was developed, based on the issues identified earlier, covering corporate background (company industry and size, KM program specifics, resource allocations), KM drivers (forces advancing KM), KM implementation (planning, tools, barriers, and overall effectiveness), better practices (details on successful efforts), organizational culture (and impact on KM), metrics (measuring KM), and overall comments (open problems, benchmarking efforts, surprises, use of consultants, etc.).

Nineteen companies were selected for participation in the first quarter of 2000 based upon their involvement with this program and/or recognition for KM leadership: 3M, Air Products and Chemicals, Akzo, A. O. Smith, Aurigin, Becton-Dickinson, Bombardier (Canada), BP Amoco, CSIRO (South Africa), Dow Chemical, DuPont, Eastman Kodak, International Paper, Monsanto, Pechiney (Canada), Raychem, Sandia National Laboratory, SmithKline-Beecham, and Unilever. (Unless otherwise identified, all were U.S.-based units.) Semi-structured interviews of one hour or more were held with key executives involved in knowledge management (KM) activities at these corporations.

Proceeding in accordance with an agreement for non-specific attribution, practices, learnings and concepts were then coded and analyzed utilizing content review and interview mapping techniques. Over 300 contributions were sorted by topic and reviewed for trends, exceptions and outlier examples by members of the team. The results were the basis for the report, which represents an inductively derived expansion and modification of the original outline. The survey process was exploratory and thus not designed to enable statistical treatment of results, nor to test or confirm any specific hypotheses.

Initially we were looking for "better practices." As we proceeded into the interview process, we found few respondents who were willing to label their approach as a "better practice." Most claimed it was too early to know and that almost none of their results had been externally benchmarked against alternatives. Also, some practices viewed by the surveyed companies as proprietary were not shared. Therefore, we decided to gather *all* practices that were either being implemented or even considered. The KM discipline within R&D is obviously still at an early stage.—**The Authors.**

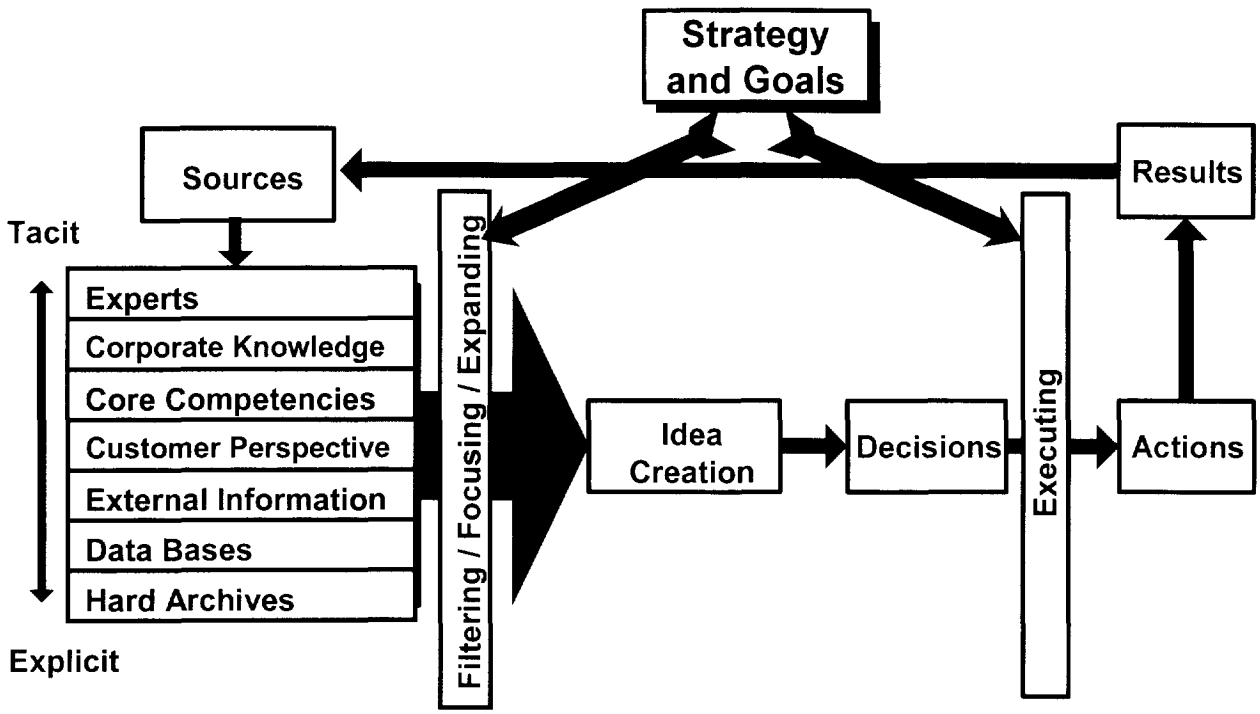

Figure 1.—In this simplified linear model of R&D, knowledge flows from internal and external, tacit and explicit sources, is processed in light of strategy to create new knowledge, and acted upon to give tangible results. Information about the results is captured for reuse.

everyone to work with it in some way to improve it. The ensuing discussions invariably helped make differences in perspective apparent or coalesce. We present the model here because it provides a relevant framework into which can be placed the individual and varied practices described later.

Figure 1 shows the original model used in early discussions with technology managers. This model is cyclic and begins to capture key elements of the R&D process. It is driven by corporate strategies and goals that cascade down to the R&D organization, whereupon premises are formulated for valuable new products, platforms or extensions. The existing sources of knowledge are utilized to validate the premises and create new ideas. The sources—i.e., the information and knowledge base—are represented as a continuum from tacit to explicit knowledge. Tacit knowledge is contained in an expert's head; databases and hard archives such as books and reports exemplify explicit knowledge. Sources like corporate knowledge, core competencies, customers' perspectives, and external information, are combinations of tacit and explicit. Potentially useful information is filtered and focused through the lens of strategies and goals. Data and information must be sifted and worked to become more relevant to the premises.

In addition, there is an expanding element that is present when individuals and teams discuss and review the information they have obtained. The expansion process creates new knowledge beyond that contained in the individuals' heads. This is the "between mind's knowledge" related to interactions that take place between individuals and within teams. It is out of this filtering, focusing and expanding process that the ideas for research are created. Because the pursuit of knowledge creation is central to innovation and thus critical to R&D, leaders expend an extraordinary amount of effort to develop this aspect of the knowledge flow. This strong focus is where KM for innovation differs from that for some other functions in which reuse of knowledge is emphasized.

Next comes a decision-making process in which ideas are prioritized, the most promising selected, and experimental programs put into place. As programs are executed, output is filtered again, assessing its ability to meet the strategies and goals. From this, actions are taken and results delivered. Results, either positive or negative, produce information that is returned to the sources for reuse in the knowledge flow process. The interface with external processes, such as marketing, manufacturing and so forth, generally is considered to occur through the interchange of results.

As discussed earlier, the model in Figure 1 oversimplifies the actual nature of the complex R&D process. As perhaps its greatest shortcoming, it suggests a once-

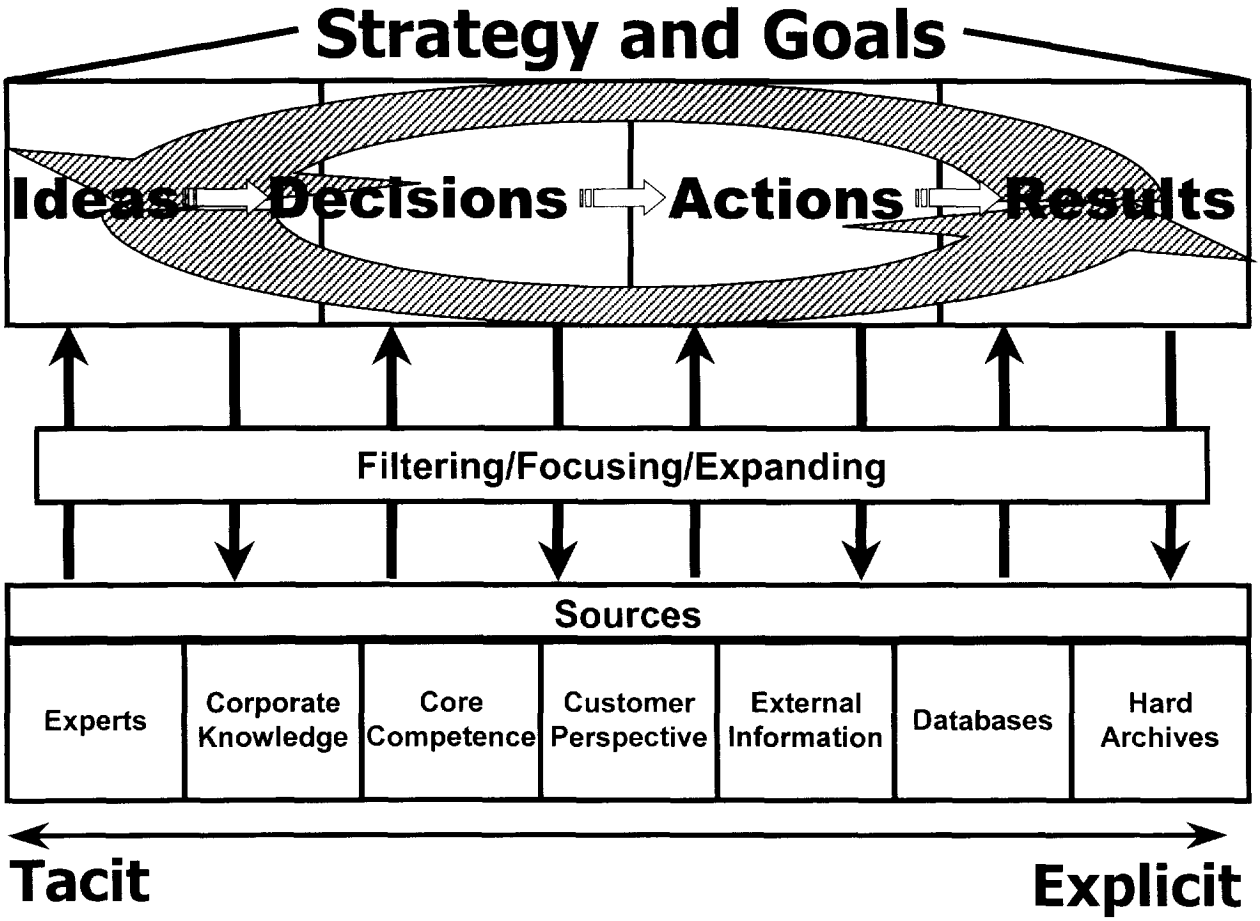

Figure 2.—Knowledge flow is non-linear; each step is continuously seeking, using and producing knowledge.

through linear operation, which is highly inaccurate. In each step—idea creation, decision-making, taking actions, and summarizing and analyzing results—new knowledge is always being created, utilized and captured. Also, at each step, the knowledge base may be accessed.

This complexity of interaction suggests a different model: a highly interpersonal and iterative process of filtering, focusing and expanding in which the creative process takes place. Figure 2 depicts a second representation of this same process.

The main difference between the two models is that people in every stage of the cyclic process from ideas through results are interacting with the sources of information and knowledge through their human filtering, focusing and expansion mechanisms. Strategy and goals continue to provide overarching guidance for the entire process. This representation captures two essential new elements:

- Continual interchange with the knowledge base.
- Recognition that innovation is not limited to R&D but resides in the whole business.

We have found that neither model alone portrays the nature of the knowledge flow process as well as the pair together. We also observe that working through the original model (Figure 1) greatly facilitates understanding of the added concepts illustrated in the second version.

Comparison with other KM Models

A number of models for KM are found in the literature (*3, 7–11*). They contain similar attributes, many of which are captured within the knowledge flow framework discussed here. Most of these propose processes that are cyclic in nature; that is, they convert tacit knowledge to explicit knowledge and through the creation of new knowledge create more tacit knowledge. An example is the well-documented approach of Nonaka, which is discussed in Part III (*3*).

Similarly, the models are process-centered, with each set in the context of some external process. Culture is often noted as a central issue. KM is described as a very people-dependent activity and largely information-technology-independent, although IT plays a role in facilitating knowledge creation, capture and reuse. It is

actually the people and their interactions that create knowledge. The models are also multi-dimensional and some are extremely complex. Few specifically address the innovation process. This is not surprising when we consider the uncertain nature of R&D and the often circuitous path that R&D individuals take in pursuit of new knowledge to meet their objectives and goals.

Finally, like the proposed models, most are conducted within the context of a purpose or goal. Certainly in the case of industrial work, the pursuit of knowledge without a purpose or goal does not create much immediate commercial value. Thus, purpose and goals from the corporation are vital elements of the knowledge flow framework.

Our conclusion is that the pair of frameworks we propose embrace many concepts found in earlier models, and additionally highlight aspects considered crucial for the innovation process.

Priority Issues

Interviews with many R&D managers about the above models revealed that the most important and often-cited issues dealt with culture and the optimum use of the company's internal knowledge base. The highest priority issues were:

- What kind of culture facilitates knowledge flow and how can it best be designed, incorporated and managed? Breaking the "knowledge is power" paradigm requires both major change and consistent leadership behavior over an extended period of time.

- How can the knowledge of experts and people leaving the organization be captured? This problem was difficult enough when retirement and death were the primary routes by which workers' knowledge became unavailable to the enterprise. Now, in an era where the paradigm is one of "knowledge worker as journeyman," an organization leaves itself much more vulnerable not only to loss but to leakage of important knowledge assets.

- What can be done to accelerate the R&D process? Although it is only one of the tools to be used, KM is expected to impact speed of R&D through quicker access and movement of the most relevant information, faster decision-making, and wider sharing of the best implementation practices.

- How can the creativity envelope within the R&D organization be expanded? Studies suggest that much of an organization's creative power resides in a relatively small set of individuals. If through effective knowledge sharing and learning this creative core could be expanded, significant increases in the overall output from R&D and significant value creation for the corporate entity would ensue.

Table 1.—Common Survey Themes.

- Drivers and Metrics
- Enablers
  - Culture
  - Infrastructure
  - IT Tools and Standards
- Knowledge Flow Practices
  - Networks
  - Sharing, Learning and Ideation
  - Training
- KM Stewardship

The findings extracted from our surveys were grouped according to the common themes summarized in Table 1 and discussed now.

Drivers and Metrics

The most often-cited driver for the pursuit of KM in R&D is acceleration of the knowledge creation process. The faster knowledge can be created, the more value a company can deliver to further its growth. If the process is made more effective, then the cost of innovation decreases. Reducing cost in manufacture of existing products is also of great value. And, in a more general sense, if KM can better align the entire organization around its goals and objectives, the result will be a desirable increase in productivity and creativity.

Although the drivers are clear, few companies are able to provide quantitative justification for a KM program. In most cases, KM programs are initiated on the basis of intuitive understanding that accessing and using untapped extant knowledge can create much more value. One company's CEO claimed the potential far outweighed the investment and attempted quantification upfront was unwarranted.

Once programs are in place, more effort is expended to show the value being captured. Again, anecdotal evidence is cited—for example, a more rapid turnaround for a business unit was noted in which KM clearly played a role.

More quantitative metrics for KM remain under development. Process metrics include the usual tracking of costs versus budget and frequency of hits on KM websites. A variety of output metrics are used. The most extensive is a year-to-year analysis of the value of the company's technology assets, including an estimate of the worth of its tacit knowledge base. (This is similar to the intellectual property valuation completed as a part of due diligence in an acquisition.) A more specific technique is to assess the *quality* of the knowledge base, that is, how current, accessible and easily updated it is. Similarly, one respondent engages an external consultant to periodically assess the readiness and the progress of

the knowledge base within the company. Another company measures the reduction of manufacturing cost as a result of sharing technical advances among its plants.

Few companies can provide quantitative justification for a KM program.

Enablers

Figure 3 overlays three "enablers"—Culture, Infrastructure and Technology—onto the framework, each active at all stages of knowledge flow. Drawn from other KM models and literature, these enablers apply equally well to the new R&D models. Culture and Infrastructure, when the latter relates to hierarchy and organization, are often linked. Because the enablers have profound effects on all aspects of knowledge creation and flow, much activity of the surveyed companies was focused on these areas. A brief mention of these areas will be made here and more detail provided in Part II.

Culture

The most often cited and, apparently, most important issue is developing a culture that values sharing and creating knowledge. There is general recognition of the need to encourage and enable individuals to interact, collaborate, teach, and learn from one another. In this way, a more useful collective knowledge is created from the sum total of individual knowledge. Many of these concepts were foreshadowed in earlier work by Senge (*12*).

In recognition that this culture must pervade the entire organization and not just R&D, the Human Resources function is often the spearhead or key collaborator for inculcating a knowledge-sharing culture. Reward and recognition systems have been redesigned to reward collaborative activity. Promotion can recognize successful application of KM to create extraordinary value for the

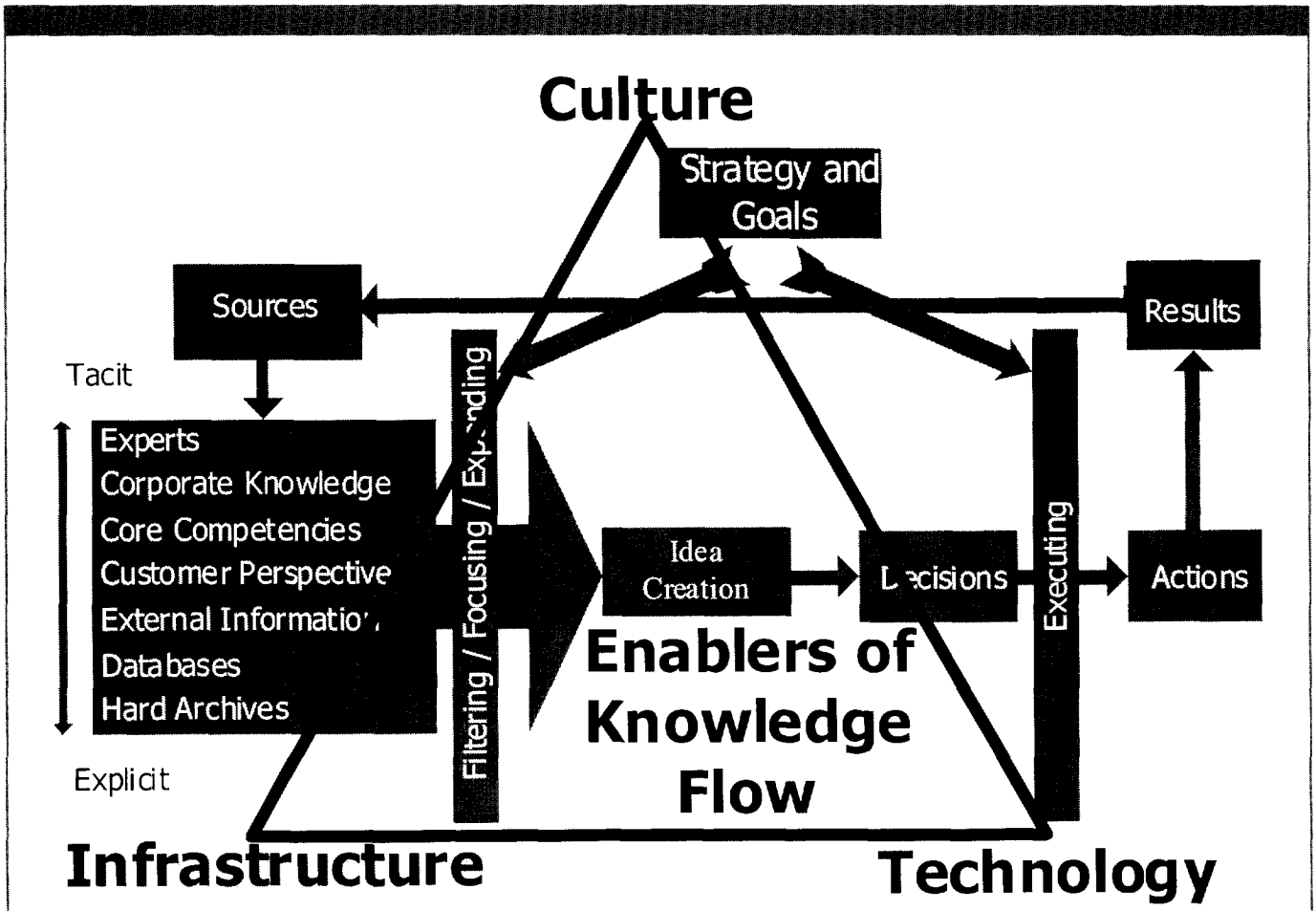

Figure 3.—The three Enablers permeate and determine the efficacy of knowledge flow for every aspect of the innovation process depicted in Figure 1.

company. "Best borrowed idea" or "shameless stealing" programs have been implemented. Company-wide events are organized to recognize business successes from KM. Hiring practices can be directed to find candidates with appropriate attitudes and disposition for contributing to a knowledge-sharing culture.

Infrastructure

This enabler refers to the impact on KM of both organizational and physical structures (see Part II). When one looks at organization, the strongest message is a negative one—a *dis*abler: silos, or hierarchical fiefdoms, are the elements most destructive to attempts to promote knowledge flow; flat, open, fluid, organizational structures offer much better support for a culture that espouses sharing. Outside the formal organization, the establishment and maintenance of learning networks provide a useful framework for nurturing knowledge flow. Critical mass and requisite diversity of background and experience are also requirements for efficient knowledge flow and ideation within organizations, from small teams to entire divisions.

The KM leadership team is usually organized informally, often with a single "manager" and a number of part-time disciples from the organization. One formal structural element mentioned was a cross-functional board to guide the on-going effort.

IT Tools, Standards and Systems

Common workstation platforms are cited quite often as a necessary base for a collaborative environment. Easy electronic mail is then possible as a first step. E-mail has been supplemented by threaded discussion platforms, which are migrating to web-enabled formats.

The use of personal intranet websites is almost universally mentioned as a means for stimulating and facilitating knowledge sharing and access. These sites can be set up as "portals"—intranet sites that collect, screen and transparently display internal and external knowledge that the user has defined as relevant. Others are structured as personal showcases with peer review, and are said to stimulate knowledge sharing and interaction.

There are two major lines of thought around the use of information technology to provide access to the tacit knowledge of an organization. One is to capture as much of the knowledge in individuals' heads as possible and archive it in a searchable database. A second approach utilizes a database or intranet web pages to allow each person in the organization to "advertise" their knowledge base and expertise. The searchable content in these so-called "yellow pages" is based on resumes, publication lists, intracompany report titles, areas of interest, etc. The thought behind this technique is that a person seeking new ideas may know a general area to query but not know specific questions. A colleague who is familiar with the general area can usually be a much richer source of knowledge than written documents. Ensuing discussions begin to create the "between the minds" knowledge mentioned earlier.

Three enablers have profound effects on knowledge creation and flow.

A hybrid approach uses a search engine in an archived database of reports, company patents, and the like, to "trace" individuals who have participated in general areas of work. Again, the payoff lies in identifying experienced people who can share their knowledge. A major positive for a system of this kind is that it requires less time from the expert to keep the database current.

Surveys suggest that the yellow page or trace systems will be used about twice as often as traditional information databases (*13*).

Regardless of the choice of technique, in order to attract users the databases and yellow pages must be:

- Well-distributed throughout the company.
- Open to all (at least to all who want to use them).
- Current.
- Easily searched.
- Readily updated by the sources so that they are sustainable and current.

Security, integrity and information leakage were initially raised as potential issues around the IT platforms employed for KM, but respondents suggest these issues have been largely resolved.

Knowledge Flow Practices

A wide range of practices has been grouped into three sets: structured person-to-person interactions or Networking, informal knowledge building and transfer covered in Sharing, Learning and Ideation, and Training, both for new employees and employees with new assignments.

Networks

Most networks focus on making connections among individuals. There are two general themes:

1. In many companies, networks of experts from diverse backgrounds are consulted on major developments. The benefit of bringing together these sources of tacit knowledge is that multiple core competencies can then be embedded in a single product concept, thereby creating a stronger, more competitive offering. These networks are also used as contact sources for simply identifying the appropriate expert for collaboration. Dubbed "roundtables" by some, they may also include one or more outside experts as full participants. For example, a university consultant might provide a window on emerging technology developments, or an independent consultant with end-user expertise may have insight into the evolution of the company's marketplace.

2. Particularly valued in larger companies are networks of experts who work in the same field but are dispersed organizationally or geographically (*14*). Often called "communities of practice," these groups were cited quite frequently for promoting sharing of tacit knowledge for the betterment of the company. Individuals may be assigned to participate in two different communities of practice or work groups so that sharing between groups can be facilitated.

Practices differ with respect to deliverables expected from these networks. Because some are informal, the agenda may be set by and for the participants who initiated the network. Those informal networks that seek corporate sponsorship may be given a specific charter. Charters are quite likely to apply to those networks formed at the suggestion of management. However, such guidance may range in complexity from simply requesting that common practice be used across a company to planning strategic development of the technology.

Sharing, Learning and Ideation

A number of different techniques were found that led to or stimulated sharing, learning and ideation within an organization. Intra-company symposia, for example, showcase technology and create an environment in which individuals can interact. Process diagrams can capture workflow visually so that people understand better how knowledge flows in the process. Knowledge maps graphically describe where knowledge resides, both within and outside the company.

In the transmission of information, compelling cases and storytelling are quite often used to promote learning and sharing. This technique goes beyond "war stories" and is being taught by KM professionals. The common techniques of Stage-Gate project and portfolio management processes were cited as offering an opportunity to share and learn within and across teams. Team debriefing during the work allows cross-functional learning and ideation, which is not only essential for the project at hand but provides useful perspective in future projects. Debriefing at the conclusion of projects brings forth and captures lessons learned about project content and process, making them available for sharing with other teams.

One company reports an extensive formal process to capture and share best manufacturing technology from plants around the world. It took time to build an atmosphere conducive for individuals to share their knowledge and experience as well as to accept suggestions for improvement. A track record of success at participating plants has created a strong demand for the services of this technology audit team.

Documentation, including but expanded beyond the traditional research reports, is still uniformly used to capture learnings and make them available through intra-company networks for broad-based sharing.

Although much has been discussed in this report about the primacy of creativity or ideation in KM for R&D, there were relatively few citations from respondents about new or unusual methods to promote it. We believe there are at least two reasons for this:

- Methods to improve creativity are offered by numerous consultants, ranging from facilitated encounters to IT tools such as "invention machines."
- The process of learning through sharing, a topic that many respondents report, often provides more-than-adequate stimulus for creative thinking. Rubbing two scientists together is a sure formula for creating sparks.

Training

Most of the training mentioned in survey responses encourages sharing:

- Upfront documentation lays out knowledge flow practices expected from individuals who enter a new project or work environment.
- A formalized immersion process with explicit tool sets can acculturate new people quickly into the team.
- New people can be added to teams assigned to work within ongoing business processes, provided these have the proper knowledge sharing activities built in. Project management and structured product development processes are examples.
- Mentors for both new and, when appropriate, experienced employees in a new environment can transfer a kind of tacit knowledge that is hard to capture in an explicit form. This includes enculturation, "how things get done around here," or who to know and ask about specific issues. Some of this knowledge is timeless but hard to articulate, often transferred to the recipient through observation of actions. Other knowledge is transient, its short shelf life precluding attempts at documentation.

KM Stewardship

Managers entrusted with KM stewardship are a relatively recent development. Over the past two years, a half-dozen managers, whose full-time assignment is to develop and deploy KM support systems, joined this study group. Most of their effort is directed toward the delivery of business impact. Often, the manager's team includes people from the business team who will stay with the business unit as information stewards when implementation is complete. Dedicated personnel quite often focus their attention toward the topic of capturing tacit knowledge and serve as information stewards within an organization. Whether knowledge manager positions will become permanent is yet to be determined.

II—Enablers of Knowledge Management—Lessons From the Field

(P. N. Friga, R. B. Chapas, G. F. Farris, and M. E. McIlvaine)

Knowledge flow always includes people, and we learned from our research that the best KM efforts are focused more on "enabling" than on "managing" the flow of knowledge. In Part II, we propose a holistic set of three enablers that can guide the KM process. Many KM efforts are ineffective due to the failure to carefully consider each of these enablers. Consequently, we first present a framework that introduces the enablers and their interrelationships; next, we examine each enabler in detail with an emphasis on inhibitors (which decrease effectiveness) and facilitators (which increase effectiveness).

An enabler is a conceptual tool used to describe a process or asset that allows an organization to achieve its objectives. The term "enabler" is increasingly used to describe KM efforts in order to stress the difficulty in traditional management control of such processes, especially knowledge creation (*15*). Our focus is on the controllable elements of KM that best enable knowledge creation, acquisition *and* transfer. In this research, three critical enablers have been identified that the surveyed companies utilize in their KM efforts: *culture, infrastructure,* and *information technology* (see Figure 4).

At the highest level is culture, the system of shared meaning within an organization that strongly influences the ways in which its members act. Although definitions of organizational culture vary, common elements include symbols, values and norms (*5*). The symbols represent important ideals to the company. Values more explicitly capture the priorities of the organization. Norms manifest themselves in routines and behavior. Culture permeates the organization and influences the infrastructure and IT. Culture has great impact and is difficult to change.

Infrastructure includes physical layouts, hierarchies and the KM business processes. This last category can

Part I Summary and Conclusions

- Although knowledge cannot be "managed," its flow can be stimulated and channeled. Knowledge flow models are excellent boundary objects to stimulate thinking about KM in R&D.
- R&D can profit from the earlier thinking in this field by assessing the practices and enablers at work in its respective organizations and filling gaps or implementing relevant better practices. Some companies already consider KM in R&D to be a source of sustainable competitive advantage—appropriately so.
- KM in R&D does have a different flavor. Instead of aiming primarily to multiply the use and value of existing knowledge, it adds a strong element of discovery of new knowledge for value creation. In addition to capture and retrieval of knowledge, with its solution grounded in information technology, the key facilitators are collaboration, sharing and individual learning, with the roots of change residing in social science and anthropology.
- A broad array of IT solutions exist for archiving and retrieving information, supporting collaboration, and searching web-based sources for information—for all parts of knowledge flow. It is important that a KM program determine the choice of IT tools rather than the reverse.
- The mind contains the most valuable knowledge, and KM is causing us to rethink the latent value of this tacit knowledge all across our organizations. Improving the capability to access, interact with, and extrapolate from the tacit knowledge base to create new knowledge will impact the core R&D process positively. There is great leverage to be created through a sharing and creative environment because tacit knowledge expands the creative potential of the entire organization when it becomes accessible.
- It is apparent that effort directed at KM in R&D is an "increasing–returns" activity at this stage in its life cycle. Many organizations are finding that their investments yield excellent returns to the business bottom line.
- Facilitation of knowledge flow and knowledge creation for R&D is in its infancy and remains an open field. There are few tried-and-true KM processes and much experimentation is underway. Because they support human interactions, these processes are less likely to be addressed exclusively by information technology. Change must take place in underlying business processes and culture, and thus will be more difficult to implement and institutionalize. Consequently, patent applications for KM processes are emerging. It will be exciting to follow progress in this field over the next few years—a follow-up study is certainly warranted. Perhaps we will learn which among the initiatives reported here will eventually emerge as genuine "better practices."

include the KM program itself. Infrastructure impacts culture and can aid or hinder the KM efforts, especially in terms of employee interaction (hence the bidirectional arrows in Figure 4).

Finally, there is information technology. Much of the KM literature is dedicated to this aspect of KM strategies, especially in terms of codification of knowledge in the organization. IT is much more than just codification of knowledge, as it can enable communication among employees and can foster innovation. The use of IT feeds back into the culture and can lead to a particular KM IT orientation. IT also has had a profound impact on infrastructure, reducing physical barriers of time and place and affecting the legitimacy of hierarchies based solely on controlled access to information.

The best KM efforts are focused more on enabling than on managing the flow of knowledge.

Organizational Culture

An organization's culture has tremendous impact on its KM efforts. Culture encompasses the behavioral norms and paradigms that guide daily life and interpersonal relationships. These norms determine which behavior is valued and which is proscribed. Culture is shaped by top management actions, business processes, priorities, incentive programs, and performance measurement.

Organizational culture often originates with the values and vision of the company's founders. It evolves gradually as the organization's environment changes and new symbols, norms and values emerge. It tends to become stable unless affected by a powerful external force, such as a financial crisis or a new CEO hired from outside. In fact, one survey company spoke of the challenges in maintaining KM momentum after a merger. Thus, an understanding of organizational culture also requires an understanding of organizational change. Formal knowledge management programs represent change for nearly all organizations.

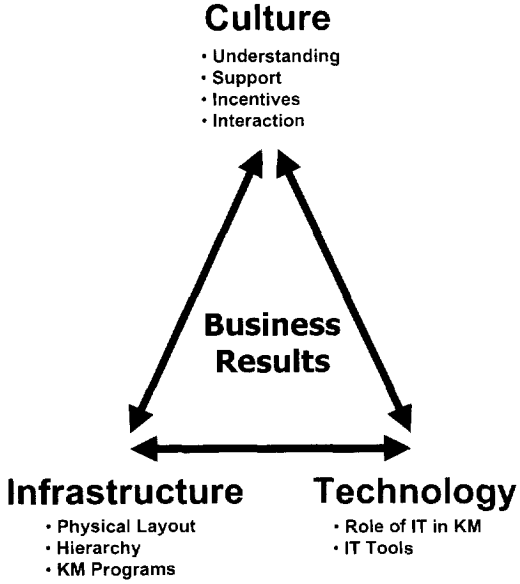

Figure 4.—Three Enablers of knowledge flow are highly interdependent and together have a major impact on knowledge creation, acquisition and transfer aimed toward business results.

Several survey questions addressed culture. The intent was to identify inhibitors and facilitators related to KM efforts. This proved to be the dominant portion of the enabler discussions. After the data were summarized and aggregated, the KM culture comments generally fell into four categories, all concerning *changing* the culture: *understanding, support, incentives,* and *interaction.* The following discussion addresses these elements—first identifying the inhibiting characteristics in each and then presenting successful facilitation strategies that can be helpful in overcoming them.

Understanding

One of the most common inhibitors revealed in the interviews was a lack of understanding related to the value of KM programs. KM was described as being "difficult to sell as it is a fuzzy concept." There is often confusion about the nature of KM efforts, specific program elements and anticipated outcomes. Getting people "on the same page" is difficult and can inhibit not only KM success but also cause the complete demise of KM programs. Past success without formal KM can also act as an inhibitor, as certain factions may not understand why change is needed.

Most of the companies with successful KM programs have specific strategies designed to combat this lack of understanding. For example, one company uses numerous presentations and training programs to promote a vision of the value of KM. Another continuously educates employees through a KM website run from the company library. Special attention is paid to new employees, especially in the case of new KM programs. Others advised regular updates of KM progress, involvement of top management, and the use of business terms and language to communicate objectives. Most of the

programs surveyed were still in the process of developing their formal KM efforts and respondents noted the importance of patience and building awareness through small successes. The old adage of "under-promise and over-deliver" may apply here.

Support

Lack of support will inhibit KM efforts in terms of resources, usage and exposure (*5,16*). Most of the more advanced KM programs identified specific top-level managers with KM responsibility. Senior management should provide a vision, visible moral support and appropriate fiscal resources for the initiative. The locus of this support has varied considerably among organizations but examples include the CEO, board members, executive councils or steering teams, and vice president of R&D. One company's president is a noted expert in the area and has written several articles on KM.

The best programs have significant support not only from top management but from all levels down to the newest company member. This support is driven by informal "champions" throughout the organization.

Many companies initiated KM pilot programs before enterprise-wide efforts were launched. There was widespread belief that "success breeds success" and support was an important element in that success. Several companies reported follow-through problems associated with waning support after exciting KM launches. A major part of achieving sustained support, as previously discussed, is gaining understanding of both the value to be created and the magnitude of the change needed to capture that value. Success does not come overnight but often follows years of hard work.

Incentives

Incentives are clearly a means of motivating behavior. With incentives, there must be some sort of measurement to identify when certain behaviors are worthy of reward. This measurement process proves to be a considerable sticking point for companies as they launch KM programs. Given the intangible nature of knowledge, it is difficult to identify clear measurement of its successful utilization. Most of the companies in this survey mentioned measurement and incentives as an inhibiting factor. A specific inhibitor pertains to the traditional individual-based incentive programs, which often interfere with KM objectives of sharing knowledge throughout the organization.

Several companies identified strategies that facilitated advances in their KM programs. One area of general agreement was to anchor performance evaluation in the business strategy and existing business objectives. There must be a link, for example, to increased sales or reduced costs. Some companies actually create measures to support KM activity. Such measures include the number of hits to certain KM internal web sites and the number of projects using knowledge from other projects. Finally, there seems to be agreement that moving more toward group-based evaluation tools would help KM efforts. In fact, one company described moving from 100 percent individual rewards in the 1980s to 20 percent in the 1990s. Not only financial incentives should be considered. Surveyed companies also mentioned public recognition program opportunities. Some believe that by making KM part of everyday life, no explicit rewards are necessary.

Senior management should provide a vision, visible moral support and fiscal resources.

Interaction

Knowledge can be transferred in two principal ways: 1) Some knowledge is captured from individuals and codified in documents and/or databases (thereby transformed to information, some would argue); when another person reads or accesses this knowledge/information, a transfer takes place. 2) Another transfer method includes no codification at all but is based on the exchange of knowledge through discussion. Companies balance between the two methods, but it is clear that employee interaction occurs with both, especially the latter.

Interaction should be encouraged for the transfer and creation of knowledge (*16*). Surveyed companies identified several inhibitors that reduce the effectiveness of such interaction. One important element is the incentive program as previously discussed. Individual incentives that don't reward team interactivity can hinder KM efforts. Another problem is the organizational "silo" wherein employees are disconnected from other employees due to structure or geography.

Finally, some companies described the protection of knowledge and information for individual and group "power" that would be lost if such knowledge were shared and/or made widely available. Secrecy within and between organizations clearly needs to be examined. The concept of "need to know" inhibits the sharing of knowledge under the justification of protecting propri-

etary knowledge. In today's fast-paced business world, the value created through knowledge sharing appears to outweigh any unreasonable emphasis on secrecy.

Many surveyed companies admitted that this protection of knowledge *internally* was an ongoing problem in the KM process and an area in which they continue to seek solutions. It appears to be less of a problem in matrix-type organizations and especially in those organizations with cross-functional teams. Training programs and shared technologies (such as Lotus Notes discussion boards and multipurpose websites) improve interaction and the sharing of uncodified knowledge. Large-scale recognition programs (such as one company's Chairman's Award for Shared Learning) also facilitate employee interaction and better KM.

In summary, of the Enablers, organizational culture may have the most significant impact on KM efforts. Those cultures that emphasize individual performance, hoarding information within units, limited employee interaction, and a lack of an involved top management inhibit knowledge sharing and establishment of effective KM programs. Only new organizations, which are still giving birth to their cultures, can implement KM programs without being strongly affected by a preexisting culture. Change in an established organization's culture is difficult, but can be accomplished through some of the mechanisms described above, particularly presenting a clearly-understood KM program, establishing support at all levels, rewarding proper behavior, and encouraging employee interaction.

Infrastructure

Infrastructure includes the physical layout of the organization, the hierarchical structure and the design of the KM program itself. Each element is important and exhibits separate inhibitors and facilitators that warrant discussion here.

Physical Layout

The physical layout is the location, size and type of offices; it also covers the type, number and nature of meeting rooms. The design of the building and work areas is a critical aspect of infrastructure, because design influences how people interact. These interactions are the principal means by which knowledge is shared in the organization. Surveyed companies identified the office design and geographic separation between business units as KM inhibitors.

Knowledge workers spend their time creating, explaining, understanding, negotiating, forming alliances, building consensus, mentoring, giving feedback, selling, persuading, inventing, solving problems, resolving conflict, and so forth. These are tasks of human interaction, not information processing or analysis. Instead of making location irrelevant, information technology, communication and transportation systems have unshackled workers, first from their desks and now from their offices—they are free to use their physical presence, more than ever, as a tool for interacting.

When it comes to such activities as negotiation, mentoring and persuasion, a person's physical presence is critical. Thus, designing a space to support this freedom and flexibility of the knowledge worker is key. Supporting the social interactions and networks that collaborative spaces and team rooms allow will ultimately enhance and improve the innovation process. One company even developed a "creativity room" for cross-functional meetings and for quiet time.

The concept of arranged workspaces to facilitate knowledge sharing is still in its infancy, but it does offer the potential to improve KM. The key features appear to be large common areas with means of visualizing knowledge—using the walls for charts, posters and white boards (*17,18*). Flexibility is also critical. The ability to rearrange offices and work areas to emphasize or focus on a project is important. With more flexible corporate structures, the challenge is to move beyond static infrastructure to a community of contributors with a clear purpose and mandate.

Hierarchy

The hierarchical structure of the organization also influences interaction. By being affiliated with a particular group, such as R&D, each member is more likely to interact with another person in this group. To reinforce this tendency, the R&D team is usually housed together. To overcome the influence of these "silos," matrix teams have been set up in which R&D, Marketing and Manufacturing personnel have common goals and report to a single manager. Matrix teams can be housed together to facilitate communication, located as a group off-site or isolated from the organization as a "skunk works." In each case, the goal is to accelerate the commercialization of a new product by creating an environment for sharing knowledge and using it in the innovation process. Care must be taken to avoid such a team becoming its own silo.

Organizationally, companies are trying to connect people and foster ownership of project objectives by disrupting traditional reporting relationships. By eliminating organizational layers, responsibility rests more clearly on the individual. By increasing the size of groups, the manager has less opportunity to micromanage and interfere with the exchange of knowledge among team members. For the same reason a heavy emphasis is being placed on leadership vis-à-vis management. By providing clear goals and acting as a facilitator, today's leaders are expected to motivate and mentor rather than provide the step-by-step methods to solve problems.

Many companies organize annual, quarterly or weekly events to bring people together and share their progress. These events take many forms, from technology fairs to roundtable discussions to scientific symposia. Often these events are held to honor a particular accomplishment. In this way, the organization defines how knowledge can be managed for success. Another method is to institutionalize networks (*14*) and communities of practice (*18*). By doing this, connections and sharing of knowledge are formalized with a clear expectation that such exchanges will occur.

Although experience with separate KM organizations is still limited, such groups certainly serve as a catalyst and represent a commitment by upper management. In today's lean organizations, to dedicate resources to KM indicates the importance placed on this activity (see below). However, for lasting success, the consensus is that KM must be a part of each person's job.

KM Program Processes

The final aspect of infrastructure involves the specific processes of KM programs in place. Companies described some consistencies and also variances in the formality, centrality, dedicated resources, and the use of outside assistance such as consultants.

The most significant barrier to successful KM efforts is a lack of dedicated resources. This clearly links to the support discussion from the previous culture section. Most companies identified at least one person with KM responsibilities and many part-time members. One company's KM team consists of the chief knowledge officer and a staff of eight full-time KM employees. Others are fledgling grass-roots efforts utilizing a few employees who "get it." Some claim that efforts without "corporate blessing" can be more successful because they must exhibit success to continue. Natural departments giving birth to KM programs include R&D, Human Resources, Information Services, and Business Intelligence.

The formality and centrality also varied quite a bit among the interviewed group. There seemed to be a general movement toward more formal programs, however, especially over the past two years. One company boasted of a successful formal KM program that had been in place for eight years. There did seem to be general agreement that the KM efforts should be cross-functional, and this supports the silo-breaking strategies discussed earlier.

Finally, about half of the companies cited the use of consultants. Those using consultants claim the most value was in the initial stages of the KM effort and in occasional reviews and follow-ups. Others believe that the effort is better developed internally. Ultimately, this can become an issue of resources and available slack.

Lack of dedicated resources is the most significant barrier.

Outside consultants can bring a fresh perspective, energy and objective design that can help to overcome cultural inhibitors.

Information Technology

Clearly, knowledge sharing is not just about technology; nevertheless, IT is an important enabler for knowledge management. Technologies that help produce, manipulate, store, communicate, or disseminate information represent what is meant by IT when used in conjunction with knowledge management. Information technology includes hardware and software, and by its general nature, encompasses technologies still under development. Two themes surfaced in IT discussions with our surveyed company representatives. The first relates to the role of IT in KM and the second includes specific experiences with IT tools.

Role of IT in KM

It became clear from the interviews that IT plays a role in KM, but the exact role varies. Contrary to much KM literature, IT is not KM. IT is better viewed in its enabler context as described above. In fact, IT may become an inhibitor if companies focus all of their energy on developing IT systems without adequate attention to the other enablers discussed here.

KM can, however, be IT-driven, as some of our companies asserted. For example, in addition to making information available in an efficient manner, IT can play an important role in breaking down infrastructure boundaries, such as functional silos and geographic spread of employees. IT can also greatly assist in the KM awareness campaigns, so important in addressing the lack of understanding and support as KM programs develop.

IT is best implemented with regard for the culture of the organization—focused on maximum utilization. Expert databases were identified as a potential problem in terms of culture: Will someone admit to being an expert if helping others is perceived to have less value than doing his or her own assigned work? Or, if a person teaches the company everything he or she knows, will the person still

be needed? Answers to questions like these link back to the incentive programs, which help define the company culture.

IT Tools

One part of our process model addresses databases of internal company knowledge. Many companies in our survey have implemented access to their own internal documentation in databases. Originally, most of these were indexing tools only, with paper copies for full reports. Increasingly, full documents are available on-line, and full-text indexed. Initially, these databases were made available to users in many different formats, but most have by now either migrated or are in the process of migrating to web-based interfaces. This brief history of access to documents illustrates one of the truths of IT: if IT can alleviate a KM problem, implement it now, in whatever is the current technology, because in five years or less something new will come along. Waiting for technology to settle down can be a long and potentially unproductive exercise.

Since KM involves sharing information, IT can be the means of storing, updating and accessing that information. Thus, companies must decide what is the most appropriate IT means for their particular organization. This includes consideration of the entire enabler framework.

One of the key decisions is the computing platform. The platform consists of the network, computers, storage, Web technologies, digital media, databases, system software, software tools, applications, and databases. It should be related to the enterprise needs and specific business objectives. Additional applications can be added as needed. Successful KM programs identified in our research employed such diverse IT collaboration tools as Lotus Notes, Web-based products, e-mail, portals, and shared white boards. Specific outputs discussed were knowledge retrieval, content publishing, business intelligence, expertise profiling, group support tools, and general information exchange.

III—Super-charge Your Innovation Process with Six KM Practices

(F. M. Ross Armbrecht, Jr., C. A. Hartz, and G. E. Whitwell)

Our intention in this Part is to propose a framework and principles for either initiating a KM effort in your innovation organization or against which to test an effort already underway (*19*). We contend that there is a minimum set or system of initiatives that must be undertaken to deliver incontestable value to your business. We choose a representative set from practices currently used by the survey companies, while providing a more complete list and detailed description than is available in Part I. We then provide some guidance for introducing KM to your organization.

Part II Summary and Conclusions

- An Enabler is a process or asset that allows an organization to achieve its KM objectives. Culture, infrastructure and information technology are key enablers.
- To realize the benefits of increasing information availability and rapid technology development, and to respond to shorter product cycles, an organization's culture, structure and IT must shift dramatically to support the needed enhancements in KM. However, these enablers are so interwoven that a change in one can result in inhibition by another unless a holistic approach is taken. Information technology and infrastructure can be changed relatively quickly; however, a sustained commitment to the desired KM practices is required to drive the slower cultural evolution.
- A culture that promotes open sharing of knowledge can be realized if leaders clearly articulate the value of the KM initiative, attract support at all levels, reward proper behavior, and encourage employee interaction. KM is facilitated by minimizing hierarchy, designing workspaces that promote interaction, and dedicating exclusive resources to it. Information technology can make it easy to access and share information and knowledge. Technology should be selected to be consistent with the cultural goals of the organization and implemented immediately instead of waiting too long for the "best" technology.
- The practices cited in Part II give only a glimpse of the array of opportunities possible. Those companies that have successfully woven KM into the fabric of their organization have been able to identify and institutionalize a collection of practices that have both "fit" and their own unique culture, infrastructure and IT enablers.

A Systemic Approach to KM

The challenge for KM is different in organizations whose lifeblood is *knowledge creation and continual learning* than it is for those for whom *better reuse of existing knowledge* is primary (*2,20*). This difference is now beginning to be understood and articulated. Naturally, then, the institutionalization of KM in research organizations has only recently begun to emerge in a broad way.

Caution is often a watchword of technical organizations. Consequently, KM efforts usually start small and are required to demonstrate some successes before full support is given. If "small" simply means applying a full-scale approach to a single, integrated business team rather than a corporation, then positive results are likely

to flow from the work of a skilled team. On the other hand, if "small" means applying a limited number of initiatives, the outcome is more in doubt. This may be compared to the task of building a car but asking that efficacy be demonstrated at the completion of the engine and windshield wipers. We contend that a minimum number of elements must be addressed simultaneously—systemically—to complete the "car" and ensure a reasonable chance that value can be demonstrated from a thoughtful and structured approach to KM.

We have chosen to discuss a set of six key imperatives based on the Knowledge Flow Model described in Part I, to categorize the "better practices" from the survey uniquely into one of the six, and then to suggest six practices, one from each imperative, that appear to "fit" together as an exemplary and coherent initial offering.

Six Imperatives

1. *Broadly instill the goals and strategies of the organization.*—As always, this leadership-driven activity is critical for success. The best companies are able to convert a normally explicit message, develop it to the extent that the entire organization can internalize it or make it tacit, and then ensure that each individual uses this knowledge to focus and prioritize all activities. The effort must include the strategies and goals of each organization in the hierarchy to which an individual belongs. Such understanding can even encourage those people on the periphery of the creative process to fully participate in it. One of many examples is the small chemical company whose janitor wrote a suggestion solving a baffling technical problem. There is no doubt that full understanding and strong affiliation with organizational goals can be a stimulus to better knowledge use and creation.

2. *Enhance access to the tacit knowledge of the organization.*—We now understand the value of, and the difficulty in, accessing current knowledge held in the minds of employees and "between the minds" of working teams. There are IT collaboration tools, war rooms, consultant-driven extraction/codification processes, and rituals such as seminars and communities of practice. The right combination can greatly help us "know what we know" and "use what we know."

3. *Provide easy "search and retrieval" tools for internal and external information.*—Because this is one area in which information technology has created such revolutionary change, most organizations have already begun to take advantage of searchable libraries of company information, Internet repositories of commercial and free information, and personalized search engines. The greater the ease of use, the more likely it is that someone will find the critical key to an innovative solution or a spark to a new idea. It is equally important to facilitate quick and easy addition of new knowledge to these repositories as it is created—in a way that the knowledge can be recovered and used by others over time.

It is absolutely critical to assess your organization's cultural tolerance for KM practices.

4. *Promote creativity.*—This area, probably because it is so critical to innovation organizations, has been researched for years. Again, there are IT tools such as invention programs, consultant-driven brainstorming/mind-mapping and lateral thinking, and structural promoters such as a stated percentage of work time with which to pursue new directions or ideas.

5. *Capture new learning for reuse.*—It is important to consider both tacit and explicit capture of new learning from the creative process, the implementation process or from customer feedback. Examples include hands-on training for other employees, sanctioned employee-to-employee teaching/learning from team or individual work, formal reports readily accessible for future use, and audits or evaluations of both successful and unsuccessful projects to improve implementation.

6. *Provide a supportive culture.*—It is absolutely critical to assess your own organization's cultural tolerance for KM practices and, if necessary, initiate those difficult, slowly achieved changes to promote knowledge seeking and sharing. Do individuals hoard their ideas for fear of losing their unique stock-in-trade? Are heroes in the organization those who collaborate or are they the "lone practitioners?" Are teams rewarded? Is a "borrowed" solution thought to be as innovative as a "new" solution when both provide the same value to the company and the market? All initiatives will succeed or fail depending on the way individuals perceive how the organization and its leaders value them—not just with words but also by their actions.

Better Practices

Table 2 lays out KM practices considered particularly useful or important by respondents to the survey. We emphasize that the survey was limited and hence the listed practices are not purported to be all-inclusive or even "best in class." Few companies were willing to

claim a given initiative as a "better practice," as almost none had yet compared themselves externally to peers. Nevertheless, we contend *mere successful use* of these practices in this embryonic area elevates them to the "better practice" status.

We have consciously used generic titles and descriptions to avoid specific endorsement of any of the excellent offerings from consulting companies or individuals, many of which address topics listed here.

Each practice has been associated with a single imperative as a best fit. Of course, many practices cut across several categories. We were pleased to see a relative balance among the six categories, not having sought that result.

From this buffet of potential initiatives, we selected one from each imperative using the following guidelines:

- Select those that will be visible and clearly drive business value.

Table 2.—"Better Practices" from the Survey, with Their Associated Imperatives.

1. **Instill Goals and Strategies.**
   - **Balanced Scorecard*—Set of metrics tied to an organization's critical business processes against which it openly and regularly measures progress, usually at corporate and business levels, and occasionally by group or function (*21*).
   - *Regular Reinforcement*—Opening all regular meetings with a review of goals and strategies, and progress against them.
   - *Integrated Developmental Business Organization*—Process of using working meetings at all levels of the organization to instill lasting understanding of the beliefs, strategies, goals, and tactics driving the corporation and the individual (*22*).
2. **Enhance Access to Tacit Knowledge.**
   - **Expertise/Skills Database*—Online locator for accessing organization members with needed expertise.
   - *Communities of Practice*—Formal or informal sanctioned cross-business networks of individuals responsible for similar classes of work, e.g., surface scientists, marketing managers, environmental specialists, polymer experts, etc. (*14*).
   - *New-pot-of-coffee Alert*—Instant message to notify group that a potential networking opportunity has been created.
   - *Project Team/Group Seminar*—Regular exposure of technical issues for suggestions on solutions, open to anyone in the organization and occasionally "spiked" with people from beyond the usual attendees.
   - *Moderated Discussion Groups*—Online running ("threaded") discussions of project/technology issues, often associated with communities of practice (see above).
   - *Collaboration Tools*—Mostly IT solutions to promote and enable working together, supporting partnerships, teams, discussion groups, etc.
   - *"Inverse" Poster Presentations*—In poster-session format, project teams present goals, issues, problems, and barriers (rather than results) for informal multiple group interactions from a broad organizational crosscut.
   - *Mind Mapping*—Structured, facilitated transfer of tacit knowledge from individuals to explicit repository.
3. **Provide "Search and Retrieval" Tools.**
   - **Portals*—Intranet sites that collect and transparently display internal and external knowledge resources.
   - *Web-searching*—Tools for exploring knowledge on an intranet and/or the Internet.
   - *Taxonomy*—Standardized information classification and indexing scheme.
   - *Technology Yellow Pages*—On-line repository of organizational technology information.
   - *Personalization*—Use of IT tools to adjust individual presentation of knowledge resources for maximum utility.
   - *Data and Textual Archives*—Repository of documentary information with indexing and retrieval capability.
   - *Desktop Library*–Online collection of information resources; may include portals, yellow pages, archives, expert databases, etc.
4. **Promote Creativity.**
   - **Intellectual Property Analysis*—Assessment of patent portfolio and internal know-how against that of competitors and customers to better define opportunities and threats.
   - *Website Analysis*—Analysis of competitor and customer websites to define opportunities and threats.
   - *Creativity Rooms*—Specific areas conducive to collaborative innovation by their placement, furnishings, wall content, equipment, etc.
   - *Data Mining*—Way to find buried knowledge by using sophisticated data search capabilities and intelligent agents based upon statistical algorithms to discover patterns, correlate data, and test hypotheses, assertions and assumptions.
   - *Outside Intervention*—Use of consultants (internal or external) who bring new thinking methodology or "invention machines" to stimulate new patterns of creative thought and idea generation.
5. **Capture New Learning.**
   - **Team Learning Through Project Execution*—Use of project management processes to promote exchange of tacit knowledge among team members in real time.
   - *Know-how Web Sites/KM Web Site*—Intranet sites that collect best practices, especially for KM.
   - *Project Process Debriefing*—Capture of project experience through team review following project completion, whether or not successful, to suggest work process improvements.
   - *e-Notebooks*—Immediate sharing and archiving of research results.
   - *Learning Center of Excellence*—Entire organization pools best practices training for leverage and synergy.
6. **Provide Supportive Culture.**
   - **Eliminate "Silos"*—Reduce internal focus and barriers between teams, functions and departments to achieve "one company" view.
   - *Management Support*– Leading by example, providing resources.
   - *Sharing Culture*—Communal exchange of knowledge as standard operating procedure.
   - *Employee Orientation/Tours/"Link" Person or Mentor*—Active indoctrination of new employees in terms of resources and culture.

*Discussed in more detail in main text.

- Focus on the need or process rather than the tool.
- Change constructively the way people access and share knowledge.
- Finish with a self-consistent set.

In addition, for the purpose of this exercise we gave less consideration to those practices that may have been in general use for some time but just not previously integrated under a KM banner. After all, this exercise is intended to be instructive rather than prescriptive and is done so acknowledging two factors: first, the situation and evolution of the reader's company will likely point to a different and equally effective collection of starter practices; secondly, at this stage in the KM life cycle, practices are evolving rapidly and today's collection may be passé tomorrow. However, we believe the underlying six imperatives and the principles for choice will better stand the test of time. The selections are starred (*) in Table 2 and discussed below.

1. *Balanced Scorecard.*—The balanced scorecard is built upon a "whole business" philosophy that gives appropriate weights and metrics to a slate of key business process initiatives (*21*). A corporate scorecard may cover safety, shareholder value, earnings, cash flow, market share, percent of sales from new products, working capital, employee satisfaction, etc. Subunits, such as businesses, functions, plants, and geographic regions, will have their own balanced scorecards with metrics that both support the larger group and specify critical targets for the subunit to achieve. Progress is discussed regularly with all employees.

2. *Expertise/Skills Database.*—Many survey companies employ this technique to understand the breadth and depth of knowledge within their organization and to make that knowledge available to others. Individuals are invited to either join a database or put up their own web pages. These contributions contain information on the work they have done in their career, particular areas of expertise, interest, training, study, and contact information. Incentives are provided for those who participate, respond to requests for help, keep their skills list current, and solve problems through use of the methodology. An even more effective method, dubbed "Yellow Pages," makes all company documents searchable by topic, yielding the name of someone who has worked in the field of interest.

3. *Portals.*—A Portal is a Web site that provides broad access and a common interface to many types of repositories and applications, and entry to other sites on an intranet, the Internet and the World Wide Web. Portals do not generate new information but overlay connections to views. Portals can be segmented into horizontal portals (a corporate common interface delivering both structured and unstructured data and a variety of services including web searching, news, directories, discussion groups, and links to other sites) and vertical portals (centric to a specific application or business functionality).

Silo or stovepipe organizational barriers defy easy solutions.

4. *Intellectual Property Analysis.*—This oft-cited technique to spur new ideas is particularly useful because, in addition to analysis of a company's portfolio, it focuses externally on competitive activity and global leading-edge technology development. It exposes needed defensive activity as well as opportunities to better expand existing beachheads and capture relatively unexplored or underexploited areas. Results provide strong support for program initiatives. Although in limited practice for years, it is now being enhanced by visualization tools that lead to additional insight. It was chosen specifically because it is still underutilized and offers many organizations the opportunity to think beyond their normal patterns.

5. *Team Learning Through Project Execution.*—The drive for team participation in innovation processes offers an excellent opportunity for cross-group and cross-functional knowledge sharing and transfer. It has been pointed out that time constraints cause many individuals to simply accept contributions of other team members without attempting to understand the thought and thought processes behind results and recommendations. These are opportunities lost. Leading organizations suggest that team members continuously build a shared understanding of one another's insights. They can then approach subsequent stages of a project able to see their individual work in the context of the learning contemporaneously being developed by all. Such teaching/learning experiences also broaden general experience for subsequent assignments.

6. *Eliminate Silos.*—It is difficult for us to call this simply a practice, but to ignore it might completely undermine the effectiveness of any other initiative. Universally acknowledged as the greatest barrier to effective KM or the desired "sharing culture" end state, silo or stovepipe organizational barriers defy easy solutions. The culture change usually requires extremely effective, persistent leadership at all levels and, specifically, a change in reward and recognition systems. Silo walls drop only when there is a general mindset among individuals, particularly managers, that corporate knowledge

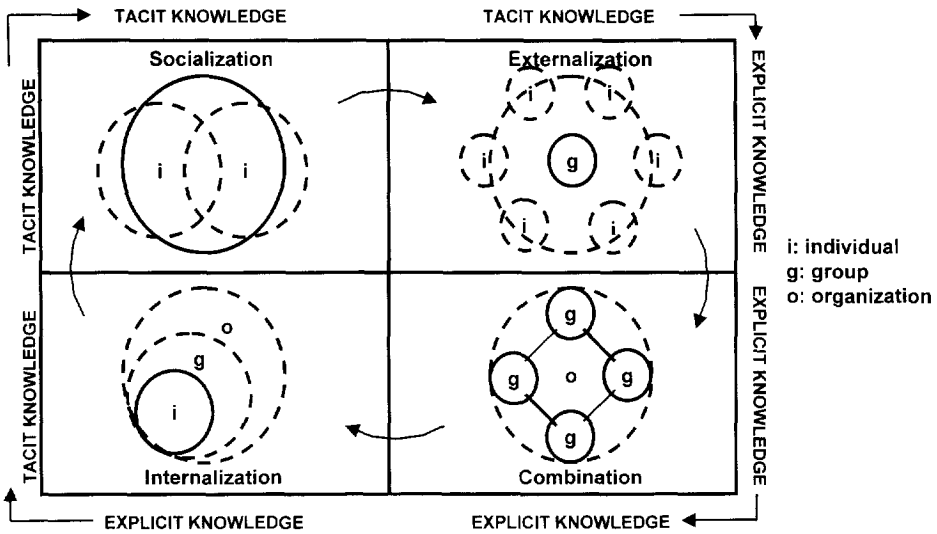

Figure 5.—In his seminal early work, Nonaka pictures knowledge cycling between tacit and explicit forms as it is expressed, shared, created or transformed, and assimilated (4).

and the people who create, carry and propagate it are *corporate assets*. One unexpected hazard in this regard is the otherwise laudable practice of team building. If it begins to promote exclusivity by the team, it can discourage appropriate calls for intellectual help both from *and by* team members.

Testing Against Other KM Models

In order to determine if we had indeed provided a systemic set of initiatives, we tested our set of starter practices against two of the many other models that describe knowledge flow. Does our set cover the various important segments in these other schemes? The first alternate is the classic flow of knowledge described by Nonaka (*4*). The second is a classification of practices adapted from Skyrme (*23*).

The Nonaka model (Figure 5) suggests that group, team and individual creative modes of the collaborative innovation process all depend on the exchange of knowledge between two forms, tacit and explicit. Tacit knowledge is that which is resident within a single person's brain or an organization's culture—"the way we do things here." Explicit knowledge is that which is codified, verbalized, digitized, or otherwise rendered in a form suitable for exchange or archiving. Nonaka describes four aspects of a knowledge cycle that occurs between these two forms:

The individual combines or modifies tacit knowledge to create new tacit knowledge. This tacit knowledge is verbalized or codified for transmission or storage as explicit knowledge. A group- or technology-driven process can combine or modify explicit knowledge to create new explicit knowledge. The cycle is closed with the process of assimilation of verbal or coded knowledge (explicit to tacit). A vibrant innovation system will have a complex web of tools and processes for fostering each of the four aspects of the knowledge cycle. Table 4 suggests that the set of six starter practices distributes attention among all four aspects of the Nonaka cycle.

Skyrme suggested a Knowledge Management/Mind Tools classification (Table 3) that can be used to identify various knowledge-sharing and knowledge-generation processes and enabling tools. At the highest classifi-

Table 3.—Knowledge Management Mind Tools Classification by Skyrme (23).

Creative Catalysts	Codification and Archived Learning
• **Thinking:** *Assimilation and Interpretation.* Concept mapping, pattern discovery, summarization, judgment, intelligence synthesis.	• **Content:** *Gathering and Retrieval.* Preparation, classification, search, index, filter, warehouse information.
• **Collaboration:** *Interaction and Communication.* Conversation, decision support, workflow process support, knowledge sharing, resource sharing, community building, skills measurement.	• **Media:** *Storage and Format.* Physical, database.

cation, he identifies four umbrella categories, two of which describe "catalysts" for knowledge creation and two of which describe the management of such knowledge. By classifying the six starter practices against the Skyrme schema in Table 4, we find the starter set appears to address all four major classifications, three of which are processes and one that describes tangible asset requirements.

The results of these two simple tests are reassuring but not unexpected. The broad imperatives were based partially on the comments from respondents to the survey but also partially on our work developing the Knowledge Flow Model (Figure 1), which was found to be normative with many other models.

How To Implement Successfully

A seventh very important area for success relates not to "what" is addressed but to "how" the initiative is approached. Three sets of questions, two based on learning from the surveys and a third from the experience of the authors, should be considered:

- How much independence should KM have as an initiative? Should it stand alone or be coupled with other activities?

- What role will top management play? How necessary is this role to the success of the implementation? Are there hazards as well as opportunities?

- How shall the rollout unfold? Should KM design be complete first or developed as part of the process? If we start "small," how do we avoid reinforcing organizational separation or silos?

Across the board, our respondents advised those who wish to pursue KM implementation to closely couple their activity with some other current business initiative. One respondent made the case to her company that KM was critical to the rollout of its "Six Sigma" initiative. Others linked it to project management or structured development process initiatives. Some KM managers targeted businesses with a strategic imperative for major change. In each case a "void" was created into which KM could be introduced as a key tool for success. One might hope implementation of KM would not need that assistance but, as a subject not yet on every top executive's hot list, one must do what is necessary to attract support for this initiative with its huge, but difficult to quantify, payback.

Unlike many business initiatives, respondents split on the question of the value of visible top management support. Many respondents claimed it was critical. Others believed that a facilitated grass-roots movement was the key to a successful implementation. One KM manager felt strongly that success could be attributed to working "below the radar" of the corporation, providing value to individual businesses where results could best be seen. Clearly, successful implementations depend on the architects' understanding of their own corporate cultures and how best to drive the necessary procedural and behavioral change.

Part III Summary and Conclusions

- To improve the chances of conclusively demonstrating value to the overall business enterprise, a new KM implementation in an innovation organization should address six imperatives: instill the organization's goals and strategies, access tacit knowledge, provide search tools, promote creativity, capture new learning, and build a supportive culture.

- From the many successful practices in use, the organization should initiate at least one to address each imperative. Make each one visible, business-value driven, clearly needed by the organization, and a cultural change agent for sharing knowledge.

- Involve much of the organization in design, link it to another business initiative if possible, and plan the rollout, including management involvement, to model the culture you wish to achieve.

Table 4.—The Six Starter Practices Appear To Cover Each of the Categories in Both the Nonaka and Skyrme Models.

	Nonaka Model (*4*)				Skyrme Model (*23*)			
					Creative Catalysts		Codification and Archived Learning	
Starter Practices	T→T	T→E	E→E	E→T	Thinking	Collaboration	Content	Media
Balanced scorecard (*21*)			X	X		X	X	X
Expertise/Skills database	X	X				X	X	X
Portals				X	X	X	X	
Intellectual property analysis	X	X	X	X	X		X	
Team learning through project execution	X	X		X	X	X	X	
Eliminate silos	X			X		X		

Finally, we have learned that it is important whenever practical to use the entire organization, or diagonal crosscuts (functional, group, hierarchical, role, etc.), to help choose, design and implement the proper initiatives. This builds ownership and understanding, offers an opportunity to practice new tools and concepts, and most important, can foreshadow or reinforce the organizational culture envisioned for the end state. It also promotes design in the proper sequence: people defining the processes they need, and only then identifying and/or building the tools to support the processes.

Wherever possible, use the entire organization to help choose, design and implement the proper initiatives.

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