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# From Information Processing to Knowledge Creation: A Paradigm Shift in Business Management

*Ikujiro Nonaka, Katsuhiro Umemoto and Dai Senoo*

*ABSTRACT. This paper examines how information technology (IT) can help implement the concept of "the knowledge-creating company," which we propose as the management paradigm for the emerging "knowledge society." We present our theory of organizational knowledge creation, along with actual examples of IT that are being used now or can be used in the near future by business organizations. Also, several differences between the Japanese- vs. Western-style organizational knowledge creation and their implications in relation to IT are discussed.*


## *Introduction*

In recent years, the vital importance of knowledge to business had been highlighted by such authors as Alvin Toffler, Peter Drucker, and James Quinn as well as by business journalists.[1] Each of these authors has heraled the emergence of a new society, referred generally to "the knowledge society." Despite all the attention, however, none of the Western authors has really examined how business organizations create new knowledge. For them, knowledge is essentially given, already exists within the organization, or can

*Ikujiro Nonaka is director at the Institute of Business Research, Hitotsubashi University, Tokyo. He received Ph.D. from University of California, Berkeley. He has authored or co-authored many books, including The Knowledge-Creating Company (Oxford University Press, 1995), and numerous journal articles on organization and innovation, several of which appeared in Harvard Business Review, California Management Review, Sloan Management Review, and Organization Science.*

*Katsuhiro Umemoto is a Ph.D. candidate in public policy and telecommunications at the George Washington University. He is now writing his dissertation on Japanese High Definition Television (HDTV) or Hi-Vision.*

*Dai Senoo is a Ph.D. student at the Graduate School of Commerce at Hitotsubashi University. He is interested in interactive relationships between organization and information technology, particularly E-mail.*

be learned or acquired from outside. Independently of this movement, the present senior author Nonaka had started building a model of how business firms create information, which has since evolved into a theory of "organizational knowledge creation."[2] Using the theory, We examine how information technology (IT) can help implement the concept of "the knowledge-creating company," which we propose as the management paradigm for the emerging "knowledge society."

## *A Knowledge-Creating Company*

Before presenting the theoretical framework, we briefly discuss a Japanese company to give an example of organizational knowledge creation. The company is Seven-Eleven Japan, the nation's largest convenience store chain, which has acquired its original licenser the Southland Corporation in the U.S. in 1991. Seven-Eleven Japan represents our concept of "the knowledge-creating company," because it synergistically fuses IT as a knowledge-creation tool and human beings with collaborative knowledge-creation abilities. Unlike most other Japanese companies, Seven-Eleven Japan makes extensive use of manuals for store operation, employee training, and franchisee recruiting, which it learned from Southland. Also, its information-logistics system centering around an advanced POS system is viewed as one of the world's best, in which even Wal-Mart is interested. Yet, the company emphasizes human intelligence and does not even think about a computerized automatic ordering-replenishing system, for which most American retailers are going.

At over 6000 Seven-Eleven stores in Japan, not only store owners but also part-timers can access detailed Point of Sale (POS) data and place orders through hand-held computers called "graphic order terminals," paying close attention to each item on the shelves and customers' buying behaviors. When placing orders, they hypothesize what items would sell well, how many, and how to sell them, based on their tacit knowledge, such as experience-based intuition, as well as on explicit knowledge or a set of information such as POS data, advice of "field counselors" from Seven-Eleven Japan's local offices, information acquired from chats with customers, or information about weather forecasts, local events, and so on. Each hypothesis is tested by an actual order and confirmed or rejected by POS data. Greatly successful hypotheses are collected by field counselors, and the selected one is presented at a ***weekly*** conference at the headquarters, which is attended by ***all*** field counselors, top management, and headquarters staff. The field counselors bring back the hypothesis to Seven-Eleven stores they take care of and encourage them to test it in following weeks. Thus, hypotheses confirmed nationwide become organizational knowledge of Seven-Eleven Japan. Through this weekly cycle of organizational knowledge creation, Seven-Eleven Japan has become the nation's most profitable retailer in both sales-profit-ratio and absolute terms.

## *The Process Of Organizational Knowledge Creation*

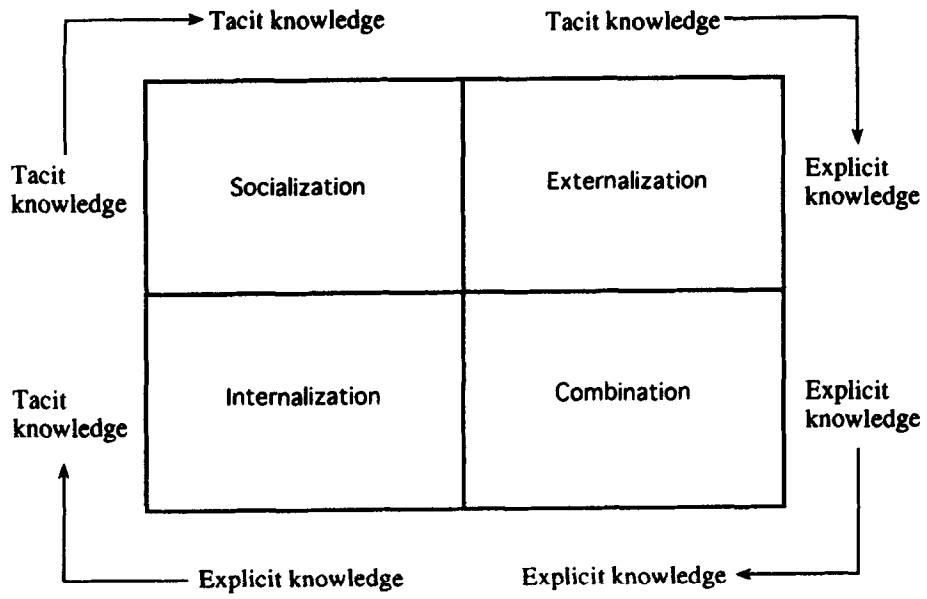
In this section, first we discuss knowledge *per se* and then the process of organizational knowledge creation along with actual uses of IT in the process. Western epistemology (i.e. philosophical inquiry or theory of knowledge) has traditionally defined knowledge as a "justified true belief." This well accepted definition, however, fails to include physical skills or embodied knowledge. Adding the bodily dimension, we define knowledge as "a meaningful set of information that constitutes a justified true belief and/or an embodied technical skill." Thus, we view knowledge creation as "a dynamic human process of justifying a personal belief toward the truth and/or embodying a technical skill through practice."

As suggested above, there exist two types of knowledge: i.e., *tacit knowledge* (e.g. intuitions, unarticulated mental models, or embodied technical skills) and *explicit knowledge* (i.e. a meaningful set of information articulated in clear language including numbers or diagrams).[3] The Japanese tend to consider knowledge as primarily "tacit," i.e. personal, context-specific, and not so easy to communicate to others, let alone via computers. Westerners, on the other hand, tend to view knowledge as "explicit," i.e. formal, objective, and not so difficult to process with computers.

In our view, these two types of knowledge are not totally separate but are mutually complementary entities. They interact with and interchange into each other in human creative activities by individuals or groups, which is the key assumption of our *dynamic* theory of organizational knowledge creation. More precisely, we assume that new organizational knowledge is created by human interactions among individuals with different types (i.e. tacit or explicit) and different contents of knowledge. This social and epistemic process brings about what we call four modes of *knowledge conversion*: i.e. *socialization* (from individual tacit knowledge to group tacit knowledge), *externalization* (from tacit knowledge to explicit knowledge), *combination* (from separate explicit knowledge to systemic explicit knowledge), and *internalization* (from explicit knowledge to tacit knowledge) (see Fig. 1). Each of these four modes of knowledge conversion will be discussed below along with examples of IT used in each mode.

### *Socialization*

Socialization is a process of creating common tacit knowledge through shared experiences. To start socialization, we need to build a "field" of interaction, where individuals share experiences at the same time and space, thereby creating common unarticulated beliefs or embodied skills. As suggested above, tacit knowledge has two dimensions: i.e. technical and cognitive. As for the technical dimension, traditional apprenticeship is a quintessential example of socialization. Young apprentices work with old master craftsmen, thereby acquiring technical skills through observation, imitation, and practice. As for the cognitive dimension of tacit knowledge, Japanese




Source: Adapted from Nonaka & Takeuchi (1995), p.62.

**Figure 1.**

companies often set up informal meetings outside the workplace, where participants have chats over *sake* and meals, thereby creating common tacit knowledge (e.g. a worldview) as well as mutual trust.

Since socialization addresses tacit information and knowledge, IT is not so useful in this mode. Only face-to-face interaction can capture the full range of physical senses and psychoemotional reactions (e.g. ease or discomfort).[4] No other communication medium is better in transmitting tacit information as major materials to build tacit knowledge. Yet, as business firms go global and "virtual" (i.e. networking), video conferences are increasingly used to exchange not only explicit knowledge but also tacit information while avoiding the traveling costs of face-to-face interaction. And as pictures and sounds of video conferences become more "high definition," it is becoming possible to exchange more tacit information. In the future, video conferences using "virtual reality" or "virtual conferences" will be realized, through which participants share a virtual 3-dimensional space as if they were in the same conference room.[5]

### *Externalization*

Externalization is a process of articulating tacit knowledge into such explicit knowledge as concepts and/or diagrams, often using metaphors, analogies, and/or sketches.[6] This mode is triggered by a dialogue intended to create concepts from tacit knowledge. Creating a new product concept is a good

example of externalization. Since the 1970s, R&D efforts have been made to develop groupware for computer-supported cooperative work (CSCW).[7] Compared with the current-generation groupware (e.g. Lotus Notes) that emphasizes the construction of knowledge-bases and the utilization of *existing* explicit knowledge, recent endeavors have been focused on the development of more advanced groupware to support the creation of new knowledge.[8] "Colab" is one of the first of its kind, a computer-supported conference system, which has been being developed by Xerox's Palo Alto Research Center (PARC). It consists of three sub-systems: (1) "Bordnoter" or an electronic blackboard; (2) "Cognoter" for brainstorming, organizing, and evaluating information; and (3) "Argnoter" for presenting, arguing, and evaluating ideas. Its design principle is information sharing, which is dubbed as "WYSIWIS (What You See Is What I See)."[9]

In Japan, a card-based knowledge-creation technique called the KJ method has been used by many Japanese companies to brainstorm, evaluate, and organize information.[10] Therefore, R&D for groupware has focused mainly on the computerization of the KJ method. A prototype example is the workstation-based GrIPS (Group Idea Processing System), which is being developed by Fujitsu, to help a group of users create ideas through two phases. During the divergent thinking phase, each member picks up data such as key words, key phrases, or pictures which he or she thinks are relevant to a discussion topic from databases called "Keyword Associator" and "Picture Library," and put them into "cards" on an electronic blackboard named "Shared Board." During the convergent thinking phase, using a kind of word processor called "Card Editor," participants jointly organize these cards (i.e. data) into pieces of information, which are then related into a diagram (or ideas as conclusions) using an electronic drawing tool named "D-ABDUCTOR." Throughout the process, participants communicate with each other through a conference coordination system called "Miniature Meeting Room," in which participants are represented by icons and the loudness of their voices is adjusted according to their locations to increase realism.[11]

### *Combination*

Combination is a process of assembling new and existing explicit knowledge into a systemic knowledge such as a set of specifications for a prototype of new product. More often than not, a newly-created concept should be combined with existing explicit knowledge to materialize it into something tangible. Thus, this mode starts with linking different bodies of explicit knowledge. The so-called "breakdown" can be included into this mode, since to break down a concept (e.g. one for a corporate vision descended from top management) is also to create deductively a systemic, explicit knowledge. It is critical for any organizational leader to create a thought-provoking and fertile concept, or what we call a "mother concept," which gives birth to

many "offspring concepts." Yet, the goal of this mode is to build an archetype (i.e. a prototype for a new product and a working model for a soft innovation such as a new business procedure).

IT comes into full play in this mode, because the greater part of knowledge and information in this mode is explicit and easy to process with IT. An example of IT for combination is software generally called the "outline processor" (e.g. Think Tank), which helps write a logical document by dividing a theme into several sub-topics and arranging them. Also, there exist several groupware for collaborative document production. Examples include "ForComment" that allows up to 16 members to take part in the joint-writing of a document through E-mail, and more advanced "Quilt," now being developed by Bellcore, provides also functions for comments in the text or voice formats, message exchanges, and computer-supported conferences.[12] And workflow management software has been widely used for collaborative work such as product development projects that adopt concurrent engineering. Moreover, CALS (Commerce At Light Speed), which has recently aroused a lot of interest in Japan, can be viewed as IT for combining explicit knowledge at the inter-organizational level.

### *Internalization*

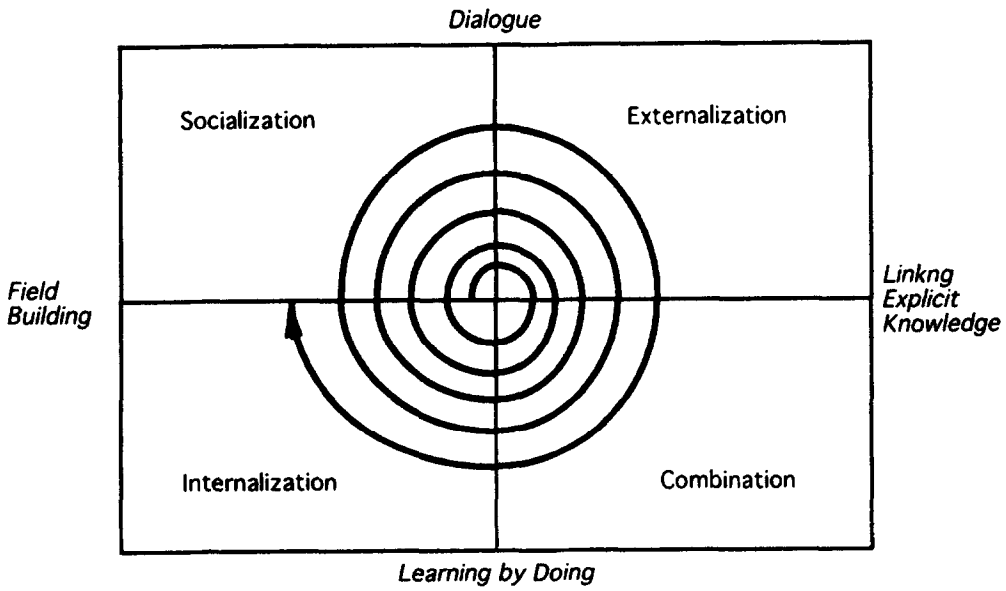
Internalization is a process of embodying explicit knowledge into tacit, operational knowledge such as know-how. This mode is triggered by "learning by doing or using." Explicit knowledge documented into text, sound, or video formats facilitates the internalization process. Therefore, manuals, quintessential explicit knowledge, are widely used for internalization. Also, engineering case studies help novice engineers to internalize explicit knowledge that has been externalized from veteran engineers' experience-based tacit knowledge of their design process. In addition to the provision of such explicit knowledge to organizational members, expanding the scope of direct experience and encouraging them to reflect upon the experience are equally important.

As IT advances, organizations have increasingly adopted training with computer simulation, instead of OJT (on the job training) plus reading manuals, thereby reducing time and cost of training. A Japanese supermarket chain, for example, uses personal computers with interactive CD-ROM recording the explicit knowledge about how to use a POS register, process cash or card payments, talk to customers, etc. for training new recruits. They can self-train themselves and take self-check tests to know how much they have internalized such explicit knowledge.[13] Moreover, personal computers for routine work have begun to include the so-called "Just-in-Time Training" function that allows users to self-train themselves, e.g. customer service representatives of Bell Atlantic, when they are not talking with customers. They can learn explicit knowledge about new services, new products, or new telemarketing techniques without being away from job, thereby reducing the time lag between learning and the actual use of such knowledge.[14]

### *The Knowledge Spiral*

Organizational knowledge is created through what we call a ***knowledge spiral*** across these four modes of knowledge conversion. A knowledge spiral may start from any mode, but usually begins from socialization (see Fig. 2). For example, "sympathized knowledge" about consumers' tacit needs may become explicit "conceptual knowledge" about a new product concept through socialization and externalization. Such conceptual knowledge (i.e. a new product concept) steers the combination phase, in which explicit knowledge in the forms of newly-developed and existing component technologies are combined to build a prototype as "systemic knowledge." Another systemic knowledge of a simulated production process for the new product turns into "operational knowledge" for mass-producing the product through internalization. And users' tacit operational knowledge about the product and factory workers' tacit knowledge about the production process are often socialized and initiate the improvement of the product or the production process or the development of another product.

In addition to this epistemological dimension of the organizational knowledge creation process, we can also visualize a knowledge spiral in the ontological dimension, namely, across the levels of knowledge-creating entities such as individuals, groups, an organization, and collaborating organizations. Individuals' tacit knowledge is the basis of organizational knowledge creation. The organization mobilizes the tacit knowledge created and accumulated at the individual level and amplifies it at the upper ontological levels




Source: Nonaka & Takeuchi (1995), p.71.

**Figure 2.**

through the four modes of knowledge conversion. At the same time, organizational knowledge is utilized and internalized at the lower levels (see Fig. 3).

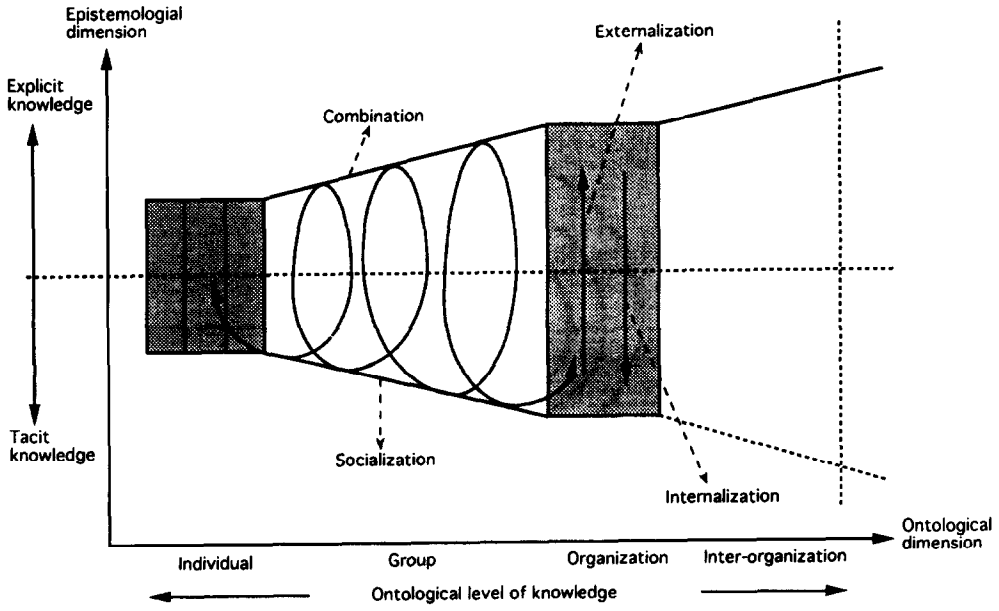
## *IT and The Five Enabling Conditions For Organizational Knowledge Creation*

The role of organization in the process of organizational knowledge creation is to support and stimulate the knowledge-creating activities of individuals and groups and to provide appropriate contexts for them. In this section, we discuss five organizational conditions that enable the knowledge spiral and how IT can enhance them.[15]

### *Organizational Intention*

The knowledge spiral is driven by organizational intention, which is defined as an organization's aspiration to its goals. Expressed as a "knowledge vision" or "knowledge domain" (e.g. Sharp's optoelectronics) and corporate standards (e.g. Sharp's "Don't imitate" imperative), organizational intention provides the most important justification criterion for judging the truthfulness and relevance of a new piece of knowledge. If not for intention, it would be impossible to evaluate the value of perceived information or created knowledge.

E-mail is a convenient tool to disseminate top management's messages. Using E-mail's broadcasting function, top management of an organization




Source: Nonaka & Takeuchi (1995), p.73.

**Figure 3.**

can send all at once a message as an organizational intention in the text or video formats to every member of the organization. And E-mail's storage function allows each receiver to take a look at the message whenever he or she likes. But as E-mail diffuses rapidly and the number of messages received goes up, it is increasingly necessary to make sure that important messages from the top be never missed. Professor Thomas Malone and his associates at MIT have developed an experimental, information-filtering system called "Information Lens" to categorize E-mail messages and select only important ones.[16] Also E-mail is now evolving into multimedia-mail in the text, voice, and video formats.

### *Individual and Group Autonomy*

All individuals and groups should be allowed to act autonomously as far as circumstances permit. Autonomy increases the chances of finding valuable information and motivating organizational members to create new knowledge. An autonomous individual functions as part of an organization with a holographic structure, in which the whole and each part share the same information. In other words, an autonomous individual is analogous to the core of a series of nested Russian dolls. From the viewpoint of knowledge creation, such an organization is more likely to have greater flexibility in acquiring, interpreting, and relating information.

Advances in IT have finally realized end-user and mobile computing, which have enhanced autonomy in terms of information and action at the both individual and group levels. Now, end-user computing is becoming the norm for any business organization. There are three factors to this trend: (1) personal computers have become more user-friendly and low-priced; (2) companies are building corporatewide information systems that include computer networks, large knowledge-bases to which every member can access, and consulting systems to help users in trouble; and (3) the rate of computer literacy is on the rise due to training (often in-house). Also, large-scale corporatewide knowledge-bases are making information-sharing a reality, breaking functional departments' information monopolies, and therefore enhancing autonomy at the group level.

### *Fluctuation / Creative Chaos*

Fluctuation is not a disorder but a change that is hard to predict. Examples include changes in market needs, growth of competing companies, and challenges given by top management. When a fluctuation is introduced into an organization, its members face a "breakdown" of routines, habits, or cognitive frameworks, and an ensuing chaotic situation. Such a breakdown gives them a chance to reconsider their basic perspectives and a sense of crisis that urges them to have dialogues with people within as well as outside the organization (e.g. customers, parts suppliers, or government officials),

thereby creating new knowledge such as novel understandings of new circumstances (sometimes new worldviews) and revolutionary corporate visions. This "order-out-of-chaos" phenomenon is called a "creative chaos."

To make intentional use of fluctuations from outside, it is necessary to monitor the environment and to communicate with outside organizations. Internet, commercial on-line information services (e.g. CompuServe), and commercial databases specialized in business, technology, and public policy can be used for those purposes. E-mail is a convenient tool to diffuse quickly an important piece of information as a "fluctuation from outside" to organizational members. Also, top management can use E-mail to send a challenging message as a "fluctuation from within" throughout the organization. But a message in the text format may not be effective to stir a sense of crisis among members of the organization. To transmit a sense of reality and urgency, therefore, a video conference system or an in-house TV network connecting multiple sites and using big-screen, high-definition displays will be increasingly used in the near future.

### *Informational Redundancy*

To Western managers who are preoccupied with the idea of efficient information processing, the term "redundancy" may sound pernicious due to its connotations of unnecessary duplication, waste, or information overload. What we mean by redundancy is the existence of information that goes beyond the immediate operational requirements of organizational members or, in other words, an intentional overlapping of information about business activities, management responsibilities, and the company as a whole. Informational redundancy promotes organizational knowledge creation in two ways. First, it facilitates the sharing of tacit knowledge, because individuals can sense what others are trying to articulate and invade each other's functional boundaries to provide pieces of advice or information from different perspectives. Second, it helps loosely-connected individuals understand where they stand in the organization and control their directions of thinking and action, which in turn provides the organization with a self-control mechanism to keep it on the track of its knowledge vision.

Redundancy of information, however, increases the amount of information to be processed and may lead to the problem of information overload. It also increases the cost of knowledge creation at least in the short run (e.g. decreased operational efficiency). Therefore, balancing between creation and processing of information is another important issue. One way to deal with the possible downside of informational redundancy is to make clear where information can be located and knowledge is stored within the organization. Large knowledge-bases using a super-parallel computer with thousands of CPUs and multiple memories are increasingly adopted for that purpose. As for information from outside, E-mail helps exchange and share them.

### *Requisite Variety*

An organization can cope with many contingencies if it has "requisite variety"[17] or minimax internal diversity, which should be a minimum for organizational integration and, at the same time, a maximum for effective adaptation to environmental changes. There are two major approaches to realize requisite variety. One is actually a set of two measures: i.e. the flattening of organizational structure and the building of a corporate-wide information system to give organizational members fast and equal access to the broadest variety of information, thereby allowing them to relate information in different, flexible, and quick manners. These measures can, on the one hand, reduce internal diversity by homogenizing members' viewpoints due to information sharing and, on the other hand, increase internal diversity by allowing current individual and functional differences in interpreting and relating the same information.

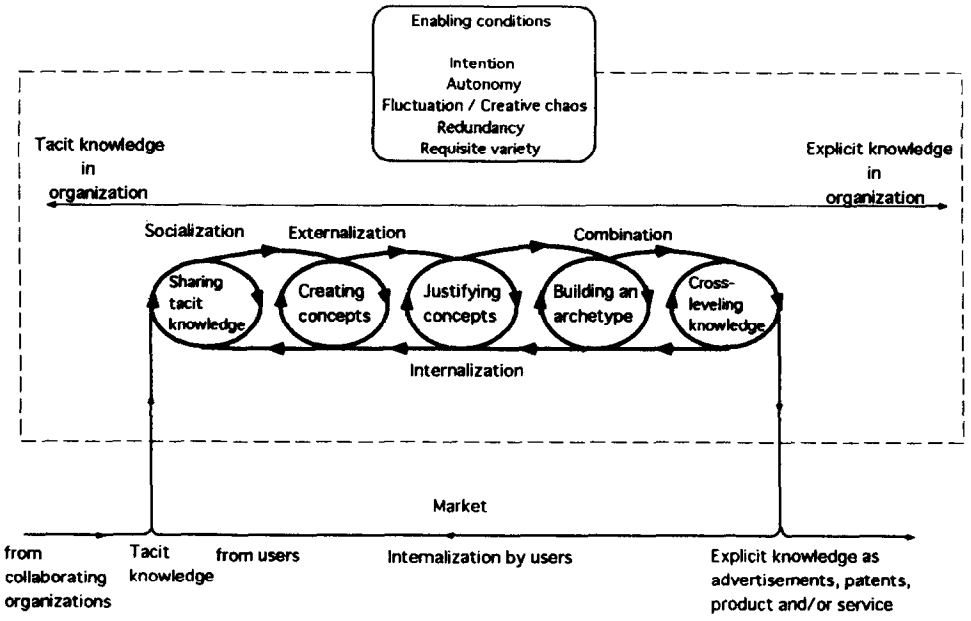
The other approach is to change the organizational structure frequently and/or to rotate personnel frequently, thereby enabling employees to acquire interdisciplinary knowledge to cope with the complexity of environmental fluctuations and internal problems. Until recently, it was difficult to implement the above measures because of problems concerning the accumulation and utilization of organizational knowledge. Large-scale knowledge-bases have solved much of the problems. The daily building of companywide knowledge-bases through groupware reduces the proprietary aspect of information and knowledge and makes it easier to take over others' duties, thus allowing frequent organizational and/or personnel changes.

### *IT and The Five-phase Model Of Organizational Knowledge Creation*

Thus far, we have argued the theoretical framework of organizational knowledge creation and the roles of IT in promoting the knowledge spiral. In this section, we present a more practical, five-phase model of organizational knowledge creation and discuss again how IT can help the process (see Fig. 4).

The organizational knowledge creation process starts usually with the sharing of tacit knowledge, which roughly corresponds to socialization. Since tacit knowledge created and accumulated at the individual level is a rich source of materials to be tapped for new knowledge, it should be shared and then amplified at the upper ontological levels. But because this phase addresses mainly tacit knowledge through shared direct experience, it is not inherently conducive to IT. Yet, as IT advances and business goes global, video technology has been increasingly used to exchange not only explicit knowledge but also hard-to-articulate associated information as much as possible.

In the second phase, tacit knowledge shared among group members is crystallized into concepts, gradually becoming explicit often through metaphors, analogies, and/or sketches. This is almost the same as the externalization process. As noted earlier, a focus of R&D for groupware is set on




Source: Nonaka & Takeuchi (1995), p.84.

**Figure 4.**

electronic tools to help group members create ideas cooperatively. To sense what others are trying to articulate, informational redundancy is critical, which is realized by knowledge-bases and a corporatewide E-mail network. As language used in this phase becomes more explicit, IT comes into play to create concepts.

The newly created concepts should be evaluated to justify its truthfulness and to decide if they deserve further work. Some groupware have such a justification function. Argonoter we mentioned earlier, for example, helps conference participants discuss and evaluate proposed ideas, first using such criteria as cost, timing, and effectiveness, and then from a viewpoint called a "belief set" that shows how deeply each participant is committed to his or her proposed ideas.[18] As noted before, the most important criterion for justification is a "knowledge vision" that defines epistemologically a "domain" a company wants to live in and provides its members with a general direction regarding what kind of knowledge they should seek and create.

In the fourth phase, the justified concepts are materialized into "archetypes," which are prototypes for new products and/or working models for soft innovations such as a new business operation procedure. As for hard prototypes, simulation technology is increasingly used to reduce the number of designing and building prototypes, thereby shortening the development lead time, which is called "virtual prototyping." Also, the so-called "visual modeling," which uses computer graphics and explicit knowledge elicited

from publications, experiments, and experts, is now being used to design a manufacturing process and to provide insights into its impacts.[19]

Organizational knowledge creation is a never-ending process. It does not end once an archetype has been built. A new concept, which has been created, justified, and realized into an archetype, moves on vertically up and down to different ontological levels and horizontally across boundaries to different divisions of the same organization or to other organizations, thereby starting new cycles of knowledge creation. We call this iterative and spiral process the "cross-leveling of knowledge." Communication media such as E-mail or a video conference system can be used for the quick cross-leveling of new knowledge.

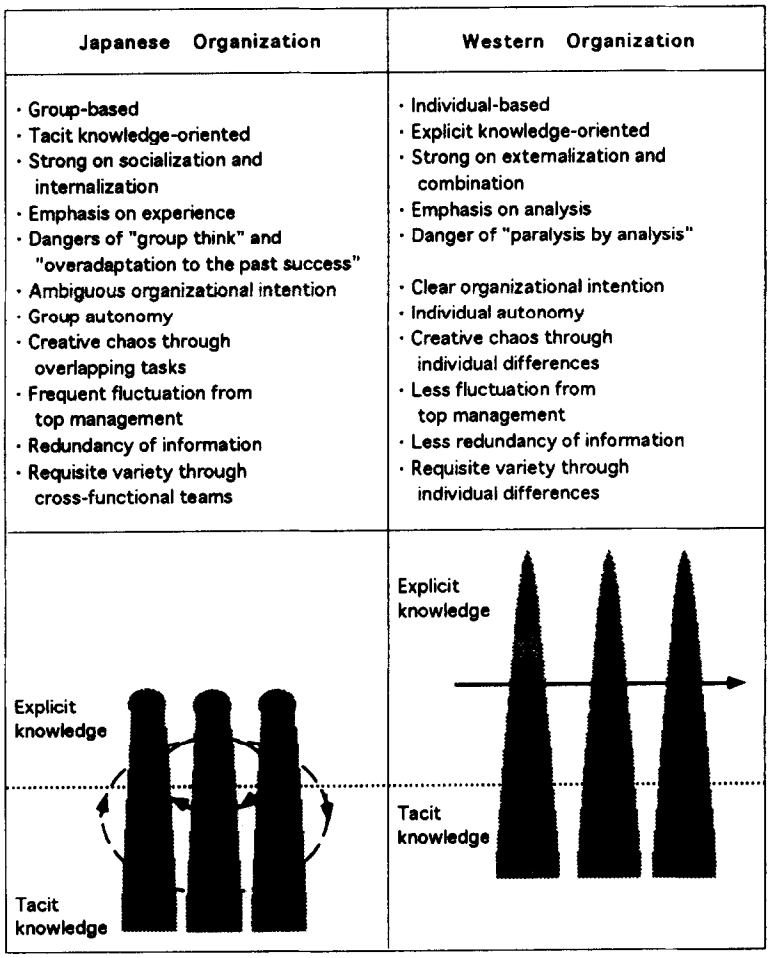
### *Differences In Japanese- vs. Western-style Organizational Knowledge Creation*

There exist several differences between the Japanese and Western approaches to organizational knowledge creation. The key differences are found in three areas. First, the interaction between tacit and explicit knowledge in the West tends to take place mainly at the individual level. That is, concepts are created through externalization efforts by top leaders (e.g. GE's Jack Welch) or product champions (e.g. 3M's Art Fry who invented Post-it Notes). In Japan, on the other hand, the interaction of tacit and explicit knowledge takes place at the group level. Japanese middle managers play the key role in two major ways: (1) they promote the socialization process of sharing tacit knowledge among group members; and (2) they lead the group members to create mid-range concepts (e.g. product concepts), drawing upon a grand concept (e.g. a corporate vision) given by top management, information sent from the business front-line, and their own knowledge. We call this management process "middle-up-down management," as opposed to top-down management and bottom-up management.[20]

Second, Western business practices emphasize explicit knowledge that is created through analytical skills and takes the specific forms of oral and visual presentations, documents, manuals, computer databases, etc. The Western-style knowledge creation can lead to the so-called "paralysis by analysis" syndrome. In terms of the knowledge conversion modes, the Western strength lies in externalization and combination. On the other hand, Japanese business people tend to use intuition, figurative (i.e. ambiguous) language, and bodily experience in knowledge creation. That is, they rely heavily on tacit knowledge. They are relatively weak in analytical skills, which are compensated by frequent interaction among people, i.e. socialization. Another strength in Japanese-style knowledge creation is internalization. Once an archetype is created, high quality tacit knowledge is quickly accumulated at the individual and organizational levels by mass-producing or implementing an archetype. The emphasis on tacit knowledge in the Japanese-style knowledge creation can lead to the so-called "group think" and the "overadaptation to the past success."

Third, the Western-style knowledge creation is characterized by clear organizational intention, low redundancy of information and tasks (i.e. creative chaos is produced by "natural" requisite variety or individual differences), less fluctuation from top management, high autonomy at the individual level, and high requisite variety through individual "natural" differences. In contrast, the Japanese-style knowledge creation is characterized by relatively ambiguous organizational intention, high redundancy of information and tasks (i.e. creative chaos through overlapping tasks), frequent fluctuation from top management, high autonomy at the group level, and high requisite variety through cross-functional project teams. Fig. 5 summarizes the differences between Japanese and Western knowledge-creating practices.

Overall, the Western-style organizational knowledge creation is more conducive to IT due to its emphasis on explicit knowledge. It is no wonder, therefore, that business applications of IT have been more advanced in the




Source: Nonaka & Takeuchi (1995), p.199.

**Figure 5.**

United States, though often at the cost of laying off people, particularly middle managers. It is often argued that corporate restructuring and IT have jointly contributed to the recent comeback of U.S. companies, whereas "reengineering" that is closely associated with those two factors is now self-criticized as "the fad that forgot people" by Thomas H. Davenport, one of the "creators" of the fashion and a professor of information management at the Graduate School of Business, University of Texas at Austin.[21] Also, it is often pointed out that Japanese companies need to make better use of advanced IT, to strengthen software capabilities, and to realize end-user computing for white-collar workers to manage "explicit knowledge" throughout the organization.

We basically agree on these arguments, but with one comment. Echoing Professor Davenport, we should warn companies laying off people with rich tacit and explicit knowledge that they would eventually lose competitive advantage. We believe that only human beings can take the central role in knowledge creation and that computers are merely tools, however great their information-processing capabilities are. Also, it is often said that corporate restructuring has reduced the level of trust among corporate members. According to Francis Fukuyama's latest book titled *Trust*, "a low-trust society may never be able to take advantage of the efficiencies that information technology offers."[22] As IT becomes more "high-definition" (e.g. HDTV), tolerant of fuzzy data (i.e. fuzzy-logic computers, a hot R&D topic, particularly in Japan), and group-oriented (see the rapid diffusion of groupware), people with rich tacit and explicit knowledge are increasingly important assets for any organizations. And once Japanese companies starts taking advantage of their group-orientedness and "high trust" that are inherently conducive to groupware, they will emerge stronger from the current slowdown.

## *Conclusion*

Professor Davenport wrote: "the lesson from reengineering is a reminder of an old truth: information technology is only useful if it helps people do work better and differently."[23] To this plain truth, we add the following conclusion. Every business organization that wants to prosper in the knowledge society should fuse synergistically IT as knowledge-creation tools and human beings with collaborative knowledge-creation capabilities to become a "knowledge-creating company." Our theory of organizational knowledge creation helps the endeavor.

## *Notes*

1. A. Toffler, *Powershif: Knowledge, Wealth and Violence at the Edge of the 21st Century* (New York: Bantam Books, 1990); P. Drucker, *Post-Capitalist Society* (Oxford: Butterworth Heinemann, 1993); J. B. Quinn, *Intelligent Enterprise: A Knowledge and Service Based Paradigm for Industry* (New York: The Free Press, 1992). See also T. A. Stewart, "Your Company's Most Valuable Asset: Intellectual Capital," *Fortune*, (October 1994), pp. 34-42.
2. I. Nonaka, "Managing the Firm as Information Creation Process," Working Paper (1987), Institute of Business Research, Hitotsubashi University, later in J. Meindl, R. L. Cardy, and S. M. Puffer (eds.), *Advances in Information Processing in Organizations*, (Greenwich, CT: JAI Press, 1991), Vol.4,

pp. 239-275; "Organizing Innovation as Knowledge-creation Process," Working Paper (1989), University of California at Berkeley; No. OBIR-41; *Chishiki-souzou no Keiei (A Theory of Organizational Knowledge Creation)* (Tokyo: Nihon Keizai Shimbun-sha, 1990, in Japanese); "The Knowledge-Creating Company," *Harvard Business Review*, (1991), Nov.-Dec., 96-104; "A Dynamic Theory of Organizational Knowledge Creation," *Organization Science*, Vol.5, no.1 (1994), pp. 14-37; I. Nonaka and H. Takeuchi, *The Knowledge-Creating Company* (New York: Oxford University Press, 1995).

3. Tacit knowledge is discussed in-depth by Michael Polanyi, a Hungarian chemist-turned-philosopher. See Michael Polanyi, *The Tacit Dimension* (London: Routledge and Kegan Paul, 1966).
4. Noria, Nitin and R. G. Eccles (eds.), *Networks and Organizations* (Boston: Harvard Business School Press, 1992), p. 293.
5. According to the 5th technological forecasting survey conducted by Japan's National Institute of Science and Technology Policy, such a "virtual conference" is forecast to be diffused by the year of 2011. *The Nikkei Industrial Daily*, August 17, 1995, p. 2.
6. For examples of metaphors and analogies, see Nonaka and Takeuchi (1995), pp. 65-67. Examples of metaphors used in IT can be found in C. D. Winslow and W. L. Bramer, *Future Work: Putting Knowledge to Work in the Knowledge Economy* (New York: The Free Press, 1994), pp. 72, 73, 106, 107, 112-116.
7. C. A Ellis defined Groupware as a "computer-based system supporting a group of users working on a common task or goal, and providing an interface to shared environment." Quoted by Hiroshi Ishii, *Designing Groupware* (Tokyo: Kyoritsu, 1994), p. 10; its original source is C. A. Ellis and G. L. Rein, "Groupware" in *Communications of the ACM*, Vol. 34, no.1 (1991), pp. 38-58.
8. IBM has already commercialized a groupware called "TeamFocus," which is an electronic conference room for idea generation and evaluation under the guidance of a human facilitator. Y. Shimizu and I. Murase, *Groupware* (Tokyo: Just System, 1995), pp. 64-66, (in Japanese).
9. Y. Matsushita, *Illustrated Introduction to Groupware* (Tokyo: Ohm, 1991), pp. 87-95, (in Japanese).
10. This method was developed by Jiro Kawakita, an anthropologist and professor emeritus of the Tokyo Institute of Technology. It consists of four basic steps: (1) writing down information (text or image) on cards; (2) grouping the cards and entitling them; (3) spatially arranging the groups and drawing charts to show relationships among them; and (4) explain the whole chart in verbal or written sentences.
11. Y. Kanda *et al.*, "GrIPS: An Groupware to Support Group-Based Idea Generation," paper presented at the *Symposium on Groupware to Support Idea Generation*, held at the Mitsubishi Research Institute in Tokyo, December, 1992, (in Japanese).
12. Ishii (1994), *op. cit.*, pp. 84-86.
13. *Nikkei Ryutsu Shimbun*, August 10 (1995), p. 4, (in Japanese).
14. *Nikkei Jobo Sutorateji*, May (1995), pp. 149-150, (in Japanese).
15. For more detailed discussions about each of the five enabling conditions, see Nonaka and Takeuchi (1995), *op. cit.*, pp. 73-83.
16. Matsushita (1991), *op. cit.*, p. 52.
17. According to W. R. Ashby, *An Introduction to Cybernetics* (London: Chapman and Hall, 1956), an organization's internal diversity must match the variety and complexity of the environment to deal with challenges posed by the environment.
18. Matsushita (1991), *op. cit.*, p. 95.
19. M. S. Alabastro *et al.*, "The Use of Visual Modeling in Designing a Manufacturing Process for Advanced Composite Structures," *IEEE Transactions on Engineering Management*, Vol. 42, no. 3 (1995), pp. 233-241.
20. For more detailed discussions about middle-up-down management and a comparison of the three management styles, see I. Nonaka, "Toward Middle-Up-Down Management: Accelerating Information Creation," *Sloan Management Review*, Vol. 29, no. 3 (1988), pp. 9-18; and Nonaka and Takeuchi (1995), *op. cit.*, chap. 5.
21. T. H. Davenport, "Why Reengineering Failed: the Fad that Forgot People," *Fast Company*, premiere issue (1995), pp. 70-74.
22. Francis Fukuyama, *Trust: The Social Virtues and the Creation of Prosperity* (London: Hamish 1995), p. 26. According to Fukuyama, the U.S., Japan, and Germany are high-trust societies; whereas China, Italy, and France are low-trust societies. He argues that trust is an important "social capital" to give such benefits as low transaction costs to business.
23. Davenport (1995), *op. cit.*, p. 74.