Chapter 11

Knowledge Processes and Knowledge Work Systems

Knowledge has become a production factor comparable to capital goods. Powerful companies thrive on knowledge (e.g., 3M, Accenture, Microsoft, and Apple). Other companies that once were successful are overrun by competition because they have neglected to advance product lines. The same applies to individual professionals. Neglecting knowledge results in failure. Knowledge management and knowledge work systems (KWS) are the key topics in this chapter. Knowledge management is a process that unfolds through several steps, and KWS play roles in each. The discussion will cover specific topics of knowledge worker, knowledge concepts and typologies, knowledge life process, Knowledge Works Systems (KWS), and knowledge culture. Understanding knowledge management and KWS also helps to understand product innovation and organizational sustainability.

Professionals as Knowledge Workers

Professionals make the occupational group whose work is most directly related to knowledge. That is why professionals are called "knowledge workers." They intensely apply (use) specialist knowledge at work. As well, knowledge workers often generate new knowledge. For example, new knowledge is created in the process of developing new goods and services. This is called product knowledge. In the case of goods, new product knowledge results from investigating materials, designing a product, and setting up the production process that delivers the product. In the case of management consulting services, a new product is a solution to some management problem, explaining what has to be done, and how to do it.

What Knowledge Is

Although many people agree that knowledge is important for survival and success of organizations, there is less agreement as to what knowledge is. To avoid usual controversies, it is good to start with some straightforward facts. When we say that someone knows how to do something (build a database, create a balance sheet, etc.), we mean that the person has memorized procedures that lead to a completion of the task. This is the understanding of how-to-do, or procedural knowledge (Figure 1). In contrast, when we say that someone knows what information system is, we mean that the person has understood and memorized a relevant concept. This is what-knowledge. And if we say that that someone knows the law of productivity, we mean that the person understands concepts of productivity factor and of productivity, and how these two relate over time (for example, improving technology as a productivity factor increases the volume of output per unit of time, that is, productivity). This is knowledge of causes and effects. Therefore, knowledge is the understanding of concepts/relations, procedures, and of causes-and-effects. These three aspects make the content of knowledge.

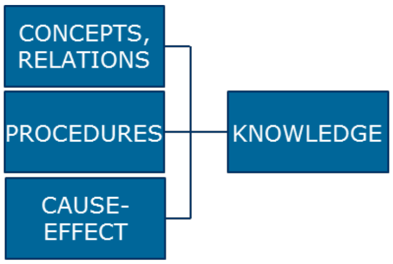

Figure 1. Knowledge content

What-knowledge includes concepts, relationships between concepts, and typologies (taxonomies). This is the basis of all knowledge. For example, you may learn definitions of IT and of IS, and understand how these two relate. Definitions and typologies are stored in the type of KWS called Document Management System.

How-to do knowledge is about performing some task-focused work. The technical segment of IS is heavy on this sort of knowledge (how to use software, different IS, how to program and maintain IS, and so on). A higher level of procedural knowledge includes procedures of complex methodologies, such as analysis and synthesis; for example, how to analyze organizational processes and data. The most complex procedural knowledge is how to generate new knowledge. That is what professionals and R+D experts master. An example is the professional called systems analyst who creates design for a new IS; the design documentation represents new knowledge. Procedural knowledge can be documented in Document Management System as well as in Case Based Reasoning System (more discussion latter in the chapter).

Understanding cause-effect relationships is the main goal of any science. This why-knowledge arises in practice as well. For example, a business manager may observe that explaining benefits of a new IS to employees leads to a quicker adoption of the system. Or an IS manager can troubleshoot a sub-optimal speed at which an IS is functioning and figure which parameters keep the speed below the benchmark. Causal relationships may be represented in the type of KWS called Expert System.

Knowledge has some properties that are important for management. The what-part of knowledge progresses incrementally in layers, while the why part may be lagging behind. Also, a learner may start with the know-how part, put it at practical test, and if results are satisfactory loose the motivation to progress toward the what- and why- parts. Moreover, knowledge develops through a process of learning. This process always has a subjective mark, even if learning happens in the group context. Thus, two persons learning from the same source may end up with knowledge that is not fully identical. All these characteristics imply that knowledge is never complete or perfectly correct and consistent. Rather, knowledge is more like a project in progress. The management implication is that an organization trying to be innovative must be able to sustain effort and cost involved with managing knowledge. As well, KWS have to be regularly updated in content and technologically updated.

Knowledge Typologies

One typology is based on *knowledge source*. It differentiates between *theoretical* and *experiential* knowledge. Theoretical knowledge you get for the most part in the school. Experiential knowledge you learn on the job by solving work problems and learning from others who have relevant experience. Experiential knowledge is sometimes called competence. A patent on new operating system produced by a software vendor represents new theoretical knowledge in the area of computer science. When this operating system is used by IS practitioners, they develop experiential knowledge about capabilities and limitations of the operating system. Theoretical knowledge is easier to represent in KWS or in paper format (books, journals) than experiential knowledge.

From the perspective of *communicating knowledge*, there is *explicit* and *tacit* knowledge. Explicit knowledge can be expressed in speech, written down, graphed and communicated in other ways. The content of explicit knowledge is what- and how-to-do-knowledge. In contrast, tacit knowledge is hard to describe in words and otherwise. It is buried deep in mind, and very hard to communicate (if at all). It is about feeling which concepts and relationships really matter, and constructing a right procedure for wrestling with new and unstructured tasks. Tacit knowledge also includes unique skills of analysis and synthesis.

Most of theoretical knowledge is explicit, while most of experiential knowledge is tacit. Tacit knowledge is a distinguishing characteristic of top experts. Management interest is to transform tacit knowledge into explicit. But this may collide with interest of knowledge owners (employees), since they may shelter their personal knowledge as something that makes them irreplaceable and more valuable than other employees. If an employee having tacit knowledge resigns, uncaptured tacit knowledge leaves with this person. This highly valuable knowledge is hard to capture in KWS, because experts may not be able to express it.

Finally, the economic view of knowledge differentiates between *human capital* and *structural capital*. Human capital is in organizational members, in their knowledge. Human capital includes both explicit and tacit knowledge, as well as theoretical and experiential knowledge. It may be the reason why investors compete for the shares of innovative companies, so that market capitalization becomes a multiple of the book value of a firm. When we say that knowledge is a production factor, we refer to human capital. In contrast, structural capital is in material artifacts, such as organizational technologies, design of business processes, production floor design, original products, and as represented in various recorded forms, including KWS. In companies that manage well knowledge, a good part of structural capital indeed is represented in KWS (see the last section on knowledge culture). The management challenge is to integrate human capital with structural. Capturing experiential and tacit knowledge in KWS is one way of doing this.

Knowledge Management Process

The knowledge management process is a sequence of activities starting with knowledge generation and ending with knowledge discarding. The process creates and maintains organizational knowledge. Knowledge process activities create a whole life cycle. Companies that manage knowledge in the process manner usually have particular management positions focused on knowledge, such as knowledge manager, patent manager, and managers in a corporate instruction centers. Some companies have raised knowledge management to the executive level by introducing the role of chief knowledge officer (CKO).

A CKO is focused on people, processes, and intellectual property in his/her company. For technological support to knowledge management, a CKO cooperates with Chief Information Officer (CIO) – the executive in charge of all information technologies and systems. In practice, knowledge managers take care of the steps (actually, sub-processes) in the knowledge management process discussed below.

Generating Knowledge

This is the first step in the knowledge management process (or knowledge life process); see Figure 2. Knowledge is generated through individual or team-based learning as employees engage in solving work-related problems and discover effective solutions of a lasting value. Models of decision making/problem solving explored in Chapter 9 apply here. For example, R+D units apply the rational model of problem solving (define problem, define solutions, evaluate and select the best solution – the first three steps in the process). Then they implement the selected solution experimentally and put a significant effort in evaluating its effects and in adjusting it (steps 4 and 5).

Sometimes good solutions are those that solve a problem that was not intended. They result from improvising, trial and error, and serendipity (luck, chance). Some big inventions were made this way, such as Scotch tape and Viagra. Working on a new kind of glue at 3M Corporation, the Scotch tape inventor first created weak glue that actually was not good for the intended purpose. But then it occurred to him that this weak glue could be applied in a different product: the removable tape was born and it became a standard office item worldwide. Similarly, the inventor of Viagra worked at Pfizer on a medical drug for improving blood circulation into the hearth. But he found through clinical testing that blood indeed circulated better within a lower part of the male body.

Generating knowledge often involves teamwork. Different experts are usually needed to come up with new knowledge and products. Placing experts in a project team is a proven management method leading to success.

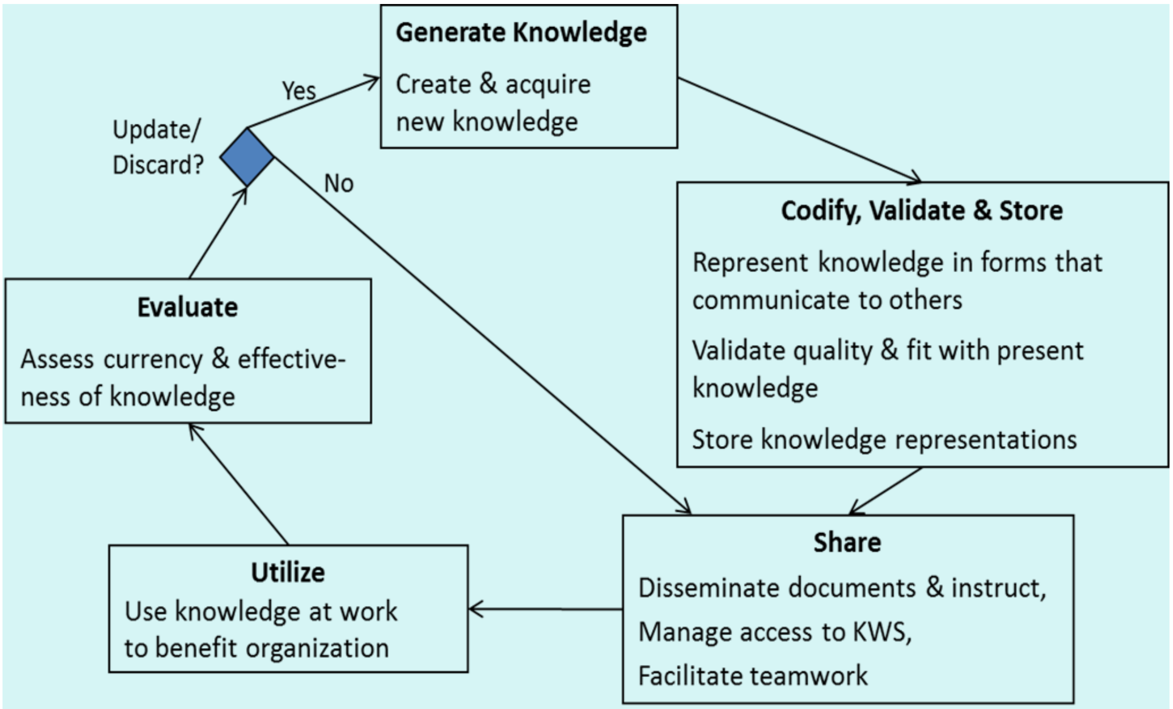

Figure 2. Knowledge management process

Codifying and Validating Knowledge

Codifying of knowledge is about representing knowledge in forms that communicate to others. The most natural way of codifying knowledge is by writing text, such as descriptions of patents and of problem solving procedures. Numerical figures are a natural way of expression for professionals who manipulate numbers, as in finance and accounting. Other forms of recording knowledge are formulas, graphics, and video. Oral accounts can be used when necessary, but one should note that talk is less precise than text.

The knowledge codification has to be performed according to the rules of a specific company. These rules are built into KWS. For example, a problem solving procedure can be stored in form of if-then statements that make the core of an Expert System. Deviating from this code would make useless the codified knowledge. The purpose of knowledge codification is to make knowledge shareable in a company. In turn, shared knowledge should improve the work of employees and reflect on the company's bottom line.

Validating knowledge follow up the codification step. This is about checking the quality of new knowledge, including accuracy, usefulness, and the fit with previous knowledge and organizational goals. These different counts of evaluation may not be in a smooth fit. For example, when Scotch tape was discovered, validation showed that the concept of new glue could results in a useful product, although it did not fit with the traditional line of the company's strong adhesives. But there are opposite examples.

When IBM developed the work station type of computer (it fits between the high-end PC and the mid-range computer), the validation step was not in favor of this new product and technological knowledge built into it. A few years later competitors created a market for this computer type, so IBM had to rush-recover its archived product knowledge to get into the market. Similarly, Digital Equipment Corporation failed to realize the usefulness and potential fit between its new network products and its mid-range and micro-computers. Revenues of the company went into a free fall, and the firm was eventually acquired.

Storing Knowledge Representations

This step finalizes the elaborate second phase (see Figure 2). Once created, representations of knowledge need to be stored. Remember that knowledge is in human mind, so only its representations can be stored externally. Such a representation is in fact highly organized data. Storing knowledge representations is a classical role for knowledge work systems (KWS), like Document Management System or Wikis today. Storage characteristics depend on the form of knowledge codification. For example, textual descriptions cannot be appropriately stored in a relational database but rather in a full-text database.

Knowledge Sharing

Sharing of knowledge refers to diffusion of knowledge and learning by organizational members. This step usually increases the value of new knowledge for a company. Disseminating knowledge documents to designated persons is a common method. Textual expression of knowledge can also be broadcast, as by blogs. Another method is by managing access to KWS - designated persons are given access privileges. Next method is corporate instruction, which can take place in specialized instructional facilities (learning centers). Finally, teamwork is a very good methods of learning by doing and communicating intensely between knowledgeable persons and learners.

Utilizing Knowledge

Utilizing knowledge refers to implementing knowledge at work. For example, an engineer uses a newly invented procedure to solve a problem at hand. Through this sub-process of the larger knowledge management process, an organization draws economic value from new knowledge. Apparently, its importance is high. But since knowledge can be utilized only if it was properly codified and stored, the actual value this step adds depends in part on the preceding knowledge management steps.

Evaluating Knowledge

Evaluating knowledge is about assessing its currency and usefulness. Although being near the end of the knowledge management process, this step is as important as generating knowledge. Particular parts of knowledge used at work needs to be evaluated in regular intervals, and a decision on keeping, updating, or discarding it has to be made. Remember that knowledge is never perfect or complete. Competitors can get ahead in product knowledge and effectively make obsolete products of a given company.

It is a crying paradox that successful companies can become victims of their own success that can make them overconfident and flatten their invention curve. This is exactly what happened to Nokia and RIM, cell phone manufactures. Once market leaders, Nokia and RIM lost the pace in creating market trends. They failed to update their product and market knowledge. Consequently, competitor products took over the market and pushed Nokia and RIM aside.

One step in knowledge evaluation is surveying company patents. When a patent expires, it is legal to imitate it. Therefore, for the patents that get closer to the expiry date, knowledge managers need to decide whether the products using these patents will be continued or not. If continued, what direction is to be taken in updating (improving) the products. An effective patent database is the one that tracks both the company's and the competitors' patents. Following the knowledge evaluation, knowledge management proceeds to deciding on the destiny of a piece of knowledge (Figure 2). It is should be used as-is, the process gets back to the knowledge sharing step. But if update or discarding is the choice, then the whole process start over again.

Knowledge Work Systems

Systems for supporting knowledge management are called Knowledge Work Systems (KWS). The following KWS types will be described in this section: Document Management System, Case-Based Reasoning System, Experts System, and Artificial Neural Network. Each has different capabilities in regard to particular steps in the knowledge management process. Table 1 shows which parts of this process are supported by particular KWS.

Table 1. Knowledge Work Systems and knowledge management process

System	Gener-ate	Codify & Store	Share	Utilize	Update
Document Management System		yes	yes	yes	
Case Based Reasoning System (CBRS)	yes	yes	yes	yes	yes
Expert System (ES)		yes	yes	yes	
Artificial Neural Network System (ANNS)	yes	yes		yes	

Document Management System

Document Management System (DMS) is a searchable repository of knowledge documentation that codifies knowledge in a formal manner. This is the most basic kind of KWS. Technically, a DMS is similar to File Sharing System, a type of group support systems. Differences are that the content of DMS refers to organizational knowledge (rather than any project document produced by a project team), and that the content is codified according to appropriate rules (while project team documents may be understandable just to team members). Also, a DMS usually has strong search capabilities. The document storage is *organized* into topics. Indexes involve content descriptors, customer names, time stamps, author names, and so on.

DMS are used by individuals and groups performing in their projects or jobs. What they utilize is in part the knowledge created by other employees at different times. DMS can be built from off-the-shelf software (e.g., IBM Notes, SharePoint, various wikis) or in a custom fashion.

Case-Based Reasoning System

Case-Based Reasoning System (CBRS) is a KWS that is based on representing knowledge as cases of problems and matching solutions. The core of a CBRS is the case base (Figure 3). The cases in it resemble the law cases that lawyers and judges regularly use in their work. There is a problem, specific circumstances, and a final solution reached. Similarly, an IS expert who tries to troubleshoot a new security problem, begins with reasoning by analogy (similarity) to known security problems. In fact, all knowledge work involves searching for similar cases that could be applied to a current case, that is, reasoning by analogy.

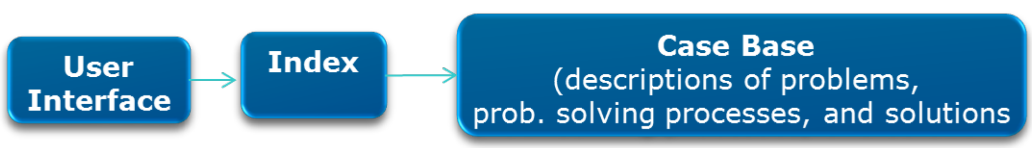

Figure 3. Design of Case-Based Reasoning System

The procedure of using CBRS involves user's input of keywords and the system's search for the best fit between the input and documents that may help in solving the user's problem.
The specific steps are:

1. The user inputs keywords describing a problem
2. CBRS matches input with the index terms
3. CBRS searches the case base for similar problems
4. CBRS outputs matched cases.

Step 2 is critical and it is performed by the index module of the system. This module is more powerful than an index used in DMS. It does not perform just matching of inputted words and index terms (full and partial matching), but it can also make decisions on a similarity of these two (so called similarity matrix).

New knowledge may also result from using CBR system. When a user retrieves past cases (step 3 in the procedure above), this is rarely the last step in problem solving. A complete match between a current and past problem can never be achieved. So, a creative effort is needed to define the final solution. By formulating it the user advances knowledge. Such advances can be recorded in the CBRS by integrating it with the retrieved cases. In effect, the case base grows spontaneously and complements the process of problem solving. This spontaneous growth of the case base during problem solving is a component of generating knowledge. Therefore, CBRS support that first step in knowledge management (Figure 2).

CBRS support the entire knowledge management process (Table 1). Main uses of CBRS are at help desks for trouble shooting, in conflict resolution, medical practice, and in professional problem solving that cannot be reduced to clear-cut if-then rules. As recording of knowledge and sharing it are the core CBRS capabilities, this system has been particularly useful for teaching and advancing various procedures. For example, a novice fund raiser may learn from a CBRS how to do fund raising. Once engaged in fund raising, the new details s/he learns are added to the existing procedure to create a variation of it. In process terms, flexibility of fund raising work gets increased. Many CBRS are custom-built for particular corporate users.

Experts System

Experts System is a KWS that is based on representing knowledge in the form of if-then rules. An example of if-then rule in banking is: If a client has a permanent job, then the client may be eligible for a mortgage loan.

An expert system is a software package that can run on a PC or a larger computer. The system has three parts shown in Figure 4. The heart of the system is the knowledge base that contains if-then rules. These are packed into decisions trees that reflect logic of if-then chaining. This is depicted in Figure 5 with a simplified example of reasoning about mortgage loans.

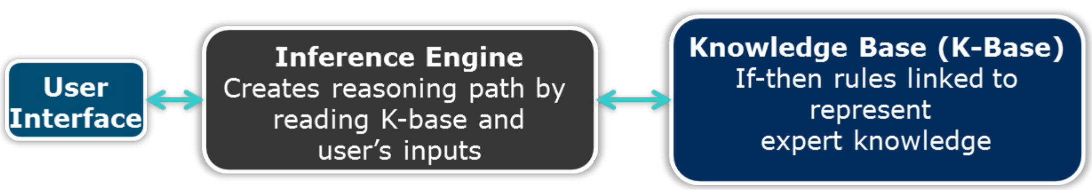

Figure 4. Design of Expert System

The user can start with a particular loan requestor and then run down the tree given the client's match with the loan conditions (permanent job, sufficient assets, sufficient income). The reasoning can also run from the end to the start, by asking the questions: who gets a loan, and who does not? Another system part is the user interface (a computer screen). Its role is to pose questions to the user and to take the user's inputs.

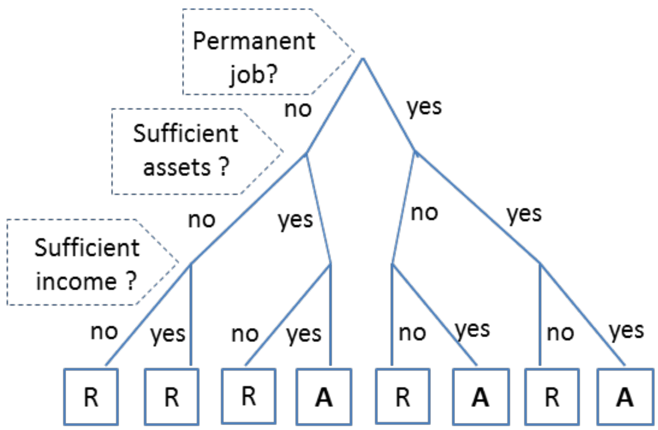

Figure 5. A part of knowledge base in expert system for mortgage loans
(A=Accept, R=Reject loan application)

Between these two parts, there is an inference engine. It reads the knowledge base and passes the questions to the user interface. In the example of mortgage loaning, the first question is "Permanent job?" If the user answer with a "yes," the inference engine starts creating its reasoning path, and looks up the next question in the knowledge base down the "yes"-line ("Sufficient assets?"). And so on. The goal of the inference engine is to reach a positive or negative conclusion about allocating a mortgage loan. The conclusion will be passed to the user interface.

The main benefits of an expert system are in codifying expert knowledge and in sharing it with other employees. These employees do not need to be experts and still can reason in an expert manner with help of an expert system. Experts systems are used extensively in account auditing. In fact, the work of modern accountant is pretty much driven by the accounting expert system. Other areas of extensive use are medical diagnosing, managing insurance claims, troubleshooting machinery, banking and other financial industry, and in analyzing soil for oil and mineral deposits.

Main costs of experts systems are associated with building a knowledge base, along with the difficulties that experts have in expressing their tacit knowledge. A disadvantage of this system type is that any knowledge base represents a narrow domain of knowledge, which cannot be stretched to unfamiliar problems. That is why it is said that experts systems are brittle when they are used on unfamiliar problems.

Artificial Neural Network

ANN System is a KWS that is based on using computer storage to simulate human brain cells (neurons) and their links that are dynamically created. For example, the ANNS in Figure 6 is used for reading a long text and reporting on its content. The system first creates a list of all words and measures their frequency. Then, the most frequent words are stored in separate storage locations (artificial neurons). Memory cells of the words that appear together in the text will be linked in the "hidden layer" of the ANNS. Every instance of joined words in the text increases the strength of a link.

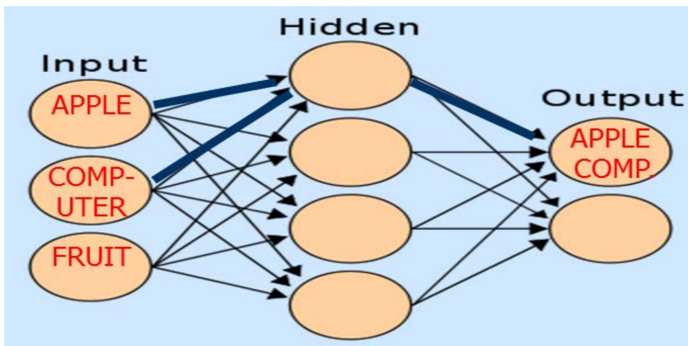

Figure 6. ANNS with three layers of artificial neurons

For this example, assume that the input text is about economy of California. The text contains words "apple" and "computer" and "fruit," among others. Yes, there is the company called Apple and stationed in California. But that state also produces the apple fruit. Is the text more about computer industry or about agriculture? The ANNS is supposed to figure that out. After the most frequent words are stored, the system investigates their co-occurrence. If the words "apple" and "computer" appear together in the text, this will be recorded in the middle layer of this ANN that is hidden to the user (basically, a structure created in the computer main memory). The same will happen with "apple" and "fruit" or "orchard," and the like agricultural terms. The output of this ANNS can be such that the words "apple" and "computer" are identified as a frequent phrase. The user can, therefore, get an idea that the text discusses the high tech sector in California's economy rather than agriculture.

The process of mapping the content is called "machine learning." ANNS can learn on its own as in this example. Optionally, ANNS can be trained to establish appropriate connections when processing inputted text ("apple " and "fruit" versus "apple" and "computer"). This is how ANNS for speech recognition works. The user reads a displayed word, and the ANNS tries to repeat it. The user repeats reading the words until the system reproduces them correctly. Note that this is not simple voice recording. Rather, the ANNS learns specific inflections in the user's voice associated with pronouncing particular letters and their combinations. The system represents digitally these findings and uses them for recognizing the user's speech in the future. ANNS-based voice recognition is part of newer versions of Microsoft's operating systems.

ANNS are also deployed in writing recognition. This powerful capability today is available even in consumer electronics, such as Tablet PC. One of characteristics that brings ANNS for visual pattern recognition closer to human capabilities is that it can work with incomplete input data. Much like people do, ANNS can recognize a particular letter even if it misses some pieces.

Organizational Culture and Knowledge

Knowledge is important for survival and success of any organization. However, some organizations excel in their approach to knowledge, as they nurture knowledge cultures. *Knowledge culture* is an organizational culture that systematically supports the entire knowledge management process. Examples are Accenture, 3M, Microsoft, Apple, McKinsey, and leading pharmaceutical companies. An indication of knowledge culture is the continuous product innovation. Teamwork has been identified as one of important factors in knowledge sharing, as it eases learning from others. It is also important for creating knowledge, particularly in high-tech and pharmaceutical companies.

Accenture is a large, global consulting company that pays systematic attention to the entire knowledge management process. Employees of Accenture share the belief that knowledge should be continually created through consulting practice and shared broadly. Managers maintain that knowledge should contribute directly to profit objectives. Technological support to knowledge management is assumed. The company has evolved its KWS over time.

Accenture managers and professionals believe that KWS should be changed as soon as serious problems in any of the knowledge processes are noted. At one point in the company's history, there were many locations at which new knowledge was created. Sharing of this knowledge was getting increasingly difficult because standards for knowledge codification were missing. Also, knowledge sharing suffered because different consultants used different indexing schemes. Accenture management decided to completely overhaul its KWS.

Accenture currently owns a document management system called Knowledge Exchange System (KES). KES serves as "organizational memory" of the knowledge created and used by Accenture consultants. Profit objectives are attached to both KES and the knowledge processes its supports.

Questions for Review and Study

1. Define knowledge and its content.

2. Why is knowledge difficult to manage?

3. Compare theoretical and experiential knowledge.

4. Compare explicit and tacit knowledge.
5. Compare human capital and structural capital.
6. Define each step in the knowledge management process.
7. List types of KWS.
8. Pick one KWS and explain how it fits into the knowledge management process.
9. Compare two KWS on similarities and differences.
10. How is knowledge codified in CBRS vs. expert system vs. DMS?
11. Pick one KWS and explain how it works.
12. What is knowledge culture? Give examples of two cultural traits and of the role of KWS.
13. How is knowledge related to product innovation?