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Knowledge Management

The Creative Loop

Jean-Louis Ermine

iSTE

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Preface

Knowledge management (KM) has become a necessity in companies and all other types of public or private organizations.

More than 20 years ago, the business community clearly entered into what is known as the “knowledge economy”. Up until that point, the forces that supported the economy were production and workforce. Now, knowledge is the primary engine for growth and competitiveness. Knowledge has become economic capital, a strategic resource, a stabilizing factor, a competitive advantage and so on. It is now a matter for an organization to capitalize on its knowledge (“Know where we come from, where we are, to better know where we are going”), to share it (“Move from individual intelligence to collective intelligence”) and to constantly create new knowledge (“Create, innovate to survive”).

Today, the issue even extends beyond the economic context, because we talk about a Knowledge Society, a Knowledge City or Smart City, etc. This falls under another point of view that depends on a new development relationship between people (citizens, workers, etc.) and Information and Communications Technologies (ICTs). The spread of ICTs will have major consequences on education, social expression, the nature of labor and the economy. Every society can establish institutions and organizations to allow people and information to flourish without restrictions. This fundamental and inevitable connection between knowledge and ICTs is now part of the dominant thought regarding knowledge societies, often to the point of inverting the predominance between ICTs and knowledge. International organizations (notably the United Nations), governments and local actors are now mobilized on these subjects.

For these reasons, KM is currently a rapidly growing field. It has returned in full force in companies, because it responds to real underlying issues that are only increasing with the phenomena of globalization, aging populations, knowledge societies, etc. There is an abundance of literature on the subject, and even providing an overview has become impossible. Identifying a clear issue in this movement, which includes the economic, social, and cultural spheres, is occurring relatively slowly, because the creation of such a field is fairly complex. It borrows from economics, management, social sciences, information systems, computer sciences, etc. Discerning what KM really is in an organization is not an easy thing, because it includes almost all of its components.

KM concerns strategy, because it is really a new type of management responding to a new socioeconomic environment and a new vision of the organization. It concerns the structure of the organization, because knowledge is made and unmade through complex networks connected to the environment that can challenge traditional systems. It concerns many processes that are already implemented in organizations (fortunately, human beings have always managed their knowledge!), but that need to be revised from new perspectives, optimized or developed. It concerns the personnel of the organization, who is at the heart of the issue, because it is true that knowledge is only created, shared or developed through people, who must mobilize personally and collectively for this purpose. It concerns information and communications technologies, which are powerful vectors for KM if they are used effectively.

It is important to have a well-founded and practical approach that can help companies implement their KM system. This is all the more necessary because the international standardization of KM is in progress through the International Organization for Standardization (ISO) and other organizations.

That is the objective of this book.

This book is the result of more than 20 years of research and experience in the field of KM, begun even before the subject arrived on the scene. It is composed of two parts that can be read independently, although they are inextricably tied.

The first part of this book consists of the theoretical part. Based on literature that reflects the diversity and depth of the research on this subject, it sets out the main concepts on which KM must be based.

The first important concept is the knowledge value chain, which relates knowledge to other connected concepts that are often more or less confused with the notion of knowledge, such as data, information, skill and capacity.

The second concept, often poorly understood and poorly defined, is that of knowledge capital, which is intangible but precious capital that all organizations have, and that is the central element of all KM policies. In fact, we can define KM in a company as the management of this company's knowledge capital. Although this definition may seem tautological, in actual fact, it is far from being put into practice.

Last but certainly not least, a third concept defined is knowledge itself. Most of the organizations that consider this problem propose their own definition of knowledge. There are hundreds of definitions that can be found in our information system that are all both similar and distinct, and they can generate interminable debates. However, the nature of knowledge is a subject that humanity has discussed almost since its origins, and many things have been thought and written on this topic, often in a very in-depth way. In this book, we propose a definition of knowledge based on a large corpus of reflections, an approach that is certainly not exhaustive, even reductive, but which is well founded and has led to the development of methods and operational tools for KM. We even sketch out a mathematical theory of knowledge.

The second part of this book consists of the practical part. It is based on 20 years of feedback and experience of a group of professionals from all types of companies (*the French KM club*), who implemented KM in their organizations and developed this experience into a KM framework, which is now nearly completed and freely available. This framework is compatible with the existing and future standards (in which it participated) and provides a practical and useful guide for companies.

This section contains an organizational part and an operational part. The organizational part concerns the implementation of a company strategy for KM and the design of a global action plan based on an analysis of the company's knowledge capital. The operational part concerns the implementation of these processes in the goal of reaching the objectives of the action plan. These processes are divided into five categories: organizing knowledge, codifying knowledge, sharing knowledge, researching knowledge and creating knowledge. This covers the existing processes to be reinforced or created that are necessary and sufficient to manage a company's knowledge capital.

We hope that this book will be useful for researchers who want to work on this topic and for professionals who want to implement all or part of a KM system in their organization.

This book is far from being an individual effort, and it benefitted from the results and collaboration of a large number of people with whom I worked.

In terms of theory, I had the support of numerous colleagues in different research teams where I have worked, at the *Université de Bordeaux*, the *Commissariat à l'Énergie Atomique* (French Alternative Energies and Atomic Energy Commission), the *Université de Technologie de Troyes* and the *Institut Mines-Télécom* (School of Management). I also shared a great deal within AGeCSO (*Association pour la Gestion des Connaissances dans la Société et les Organisations*, or the Association for Knowledge Management in Society and Organizations), which I have had the honor and the pleasure to create and preside over since 2008 and which organizes an annual conference on the subject. Thank you to everyone who shared in my journey.

At the practical level, I had the support of all the enthusiastic participants in the *Club gestion des connaissances* (French Knowledge Management Club) which I have had the honor and the pleasure of creating and presiding over since 1999. Thank you to this entire community, with whom we were able to build invaluable and useful capital based on KM.

Aware from the start that this new subject would require continuous experimentation in the field, I was the project manager or advisor for many research projects and industrial projects concerning KM in private and public organizations in France (industry, energy, transportation, defense, banks, Small to Medium-sized Enterprise (SMEs), etc.) and abroad (Algeria, Canada, United States, Brazil, Asia, United Nations, etc.). I would like to thank all of the organizations who put their trust in me and with whom I learned a great deal.

The adventure is only just beginning. I hope that this book will provide a background for everyone who wants to invest in this forward-looking field and that it will contribute to developing this domain.

Jean-Louis ERMINE
January 2018

PART 1

Theoretical Elements

1

A Knowledge Value Chain

1.1. Introduction

This chapter introduces the notion of knowledge through the concept of a value chain.

Its purpose is to clarify the relationships between the concepts of data, information, knowledge and skill, by relying on the abundant literature that has been written on these subjects. All of these concepts, which are rarely formalized and often conflated, are related and dependent, and they need to be better defined. In this chapter, this clarification results in a guidance tool to help managers understand the added value produced by knowledge and act to develop this resource.

In the “knowledge economy” [FOR 09], knowledge is viewed as a resource that is a key factor in success and the basis for a company’s competitive advantage. The objective of knowledge management (KM) is to optimize this new resource. It is therefore important to analyze the added value that KM can bring to a company. This is a difficult problem to address. For example, cost/benefit analyses for KM have never really been completed successfully. The approach proposed here is not based on the unpromising cost analysis, but on the value analysis. It is based on the nature of knowledge and its use in a company. We will see that knowledge is the result of closed-loop, continuous and simultaneous transformations within a company. We can, however, distinguish several formal transformation steps that are known as the knowledge value chain (KVC) [ERM 12]. This value

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chain is conceptual and does not presume any complexity in its implementation within a company. It is very useful for managers to locate potential sources of value of KM. The objective of the KVC is to provide an analysis and action framework that will make it possible to act on this value chain and thereby improve the company's performance.

1.2. Different KVCs

The value chain is a management concept that was developed and popularized by Michael Porter [POR 85]. A value chain is a chain of production activities in a company, from the input to the end user. The products or services pass successively through all of the activities in the chain and, with each step, the products and services acquire value. A value chain is a breakdown of a company's approach into activities that produce value. These components are the basic elements on which a company relies to create a product or provide a valuable service for their customers. The activity chain confers more added value to the products or services than the sum of the values added by each activity.

Identifying the value generated through this chain is the approach chosen by top management. The differences between the value chains of competitors are the key factors of competitiveness. In terms of competitiveness, the value is what customers are willing to pay for what the company provides them. A company is profitable if the value that it generates is greater than the costs to create the product or the service. Creating such a value is the goal of all competitive strategy. The value, instead of the cost, must be used to analyze competitive standing. The value chain characterizes the generic activities that add value to a company: the "primary activities" including logistics, production, marketing and sales and services; and the "secondary activities" including infrastructure, human resources management, R&D and supply. The vectors of cost and value are identified for each activity.

Classic value chains do not include knowledge, although it is now seen as a company's most important strategic resource [DAV 98, DRU 93, HAL 93, STA 92]. The value incorporated in products or services is essentially due to the development of resources derived from organizational knowledge

[QUI 92]. In fact, a company's ability to produce can be considered to be the integration and application of specialized knowledge collectively generated by the individuals in the company [GRA 91].

Consequently, the notion of value is not directed by the customer, as in Porter's chain, but by the incorporation of knowledge in products or services in the company's production process. This raises the question of defining more precisely what this "cognitive resource" is and how it is incorporated into the activity of a company. The goal of KM is to manage this resource integration in the company's process. KM is a fairly new perspective on companies. Its philosophy, which must still be strengthened of course, is that a company produces value for its customers when it best manages the incorporation of its cognitive resources in its products and services. Thus, very simply, KM supposes that the production of knowledge implies the production of value. KM is interested in knowledge as a strategic resource that optimizes the production processes of a company.

To support the success of KM, it is useful to analyze the chain of knowledge integration in a company in order to identify and manage the different fundamental stages of enrichment for this cognitive resource and its incorporation into company activities. This is the KVC, viewed from a global point of view in a company.

The definition of a KVC based on a financial analysis of performance is problematic [CHO 00, MPH 94]. The competence-based view business theory offers an alternative approach. This theory considers the company as a portfolio of competences. Its competitiveness is based on the creation and development of competences and on its realization of a strategy capable of creating a link between goals, resources and objectives [PRA 90]. These competences have a cognitive nature, and this allows managers to identify the basic processes, like knowledge creation and organizational learning [LEO 95, NEL 91, PRA 90]. Carlucci *et al*. [CAR 04, p. 579] assert that the cognitive perspective of competence can be summarized by the interpretation that defines the competence of a company as a combination of knowledge assets, which make up what is called the company's knowledge capital, and knowledge processes, which allow a company to successfully complete its operational processes. This provides a foundation for the definition of a KVC.

Following the considerable development of KM in the past few years, the concept of the KVC appeared and was recently debated. The authors [CAR 04, EUS 03, HOL 01, LEE 00, WAN 05] define a KVC as a set of KM processes. A KVC is therefore a KM framework organizing the basic KM processes, such as the knowledge process wheel described in Carlucci *et al*. [CAR 04]. The main processes in these different KVCs are as follows:

– knowledge creation: this is definitely the most important process, because it creates knowledge capital, the purpose of all knowledge-based companies;

– knowledge codification: this process concerns the appropriation of tacit knowledge, which is a very complex problem;

– knowledge sharing: once a knowledge corpus is identified and a knowledge repository is elaborated, sharing this knowledge in a community is not really a standard task. This requires a lot of effort starting from the construction of the appropriate community to the implementation of access infrastructure;

– knowledge dissemination: access to knowledge for most people concerned (“the right information, the right person, the right time”) is the famous problem of the “last kilometer”, it involves information and communication infrastructure, and specialized designs of dedicated systems;

– knowledge portfolio analysis: the company, to implement a KM strategy, must implement a continuous process of analyzing and characterizing its knowledge portfolio: what is its strategic knowledge? What is its available knowledge? What are the risks associated with its knowledge? etc.;

– knowledge assessment: to carry out effective KM processes, it is necessary to have an evaluation matrix for their performance.

The KVC provides a KM framework to analyze the value added by each KM process. Figure 1.1 shows an example of a KVC (from [WAN 05]), with a series of KM processes in the form of a Porter-like model.

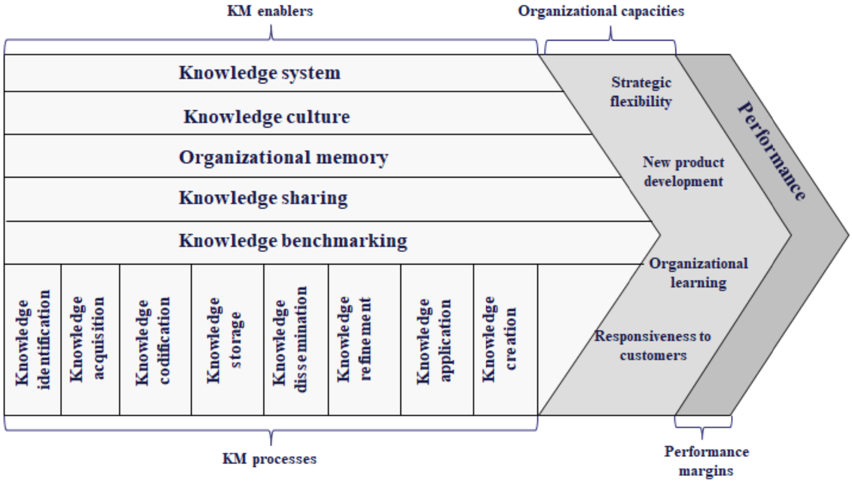

Figure 1.1. *An example of a KVC based on KM processes*

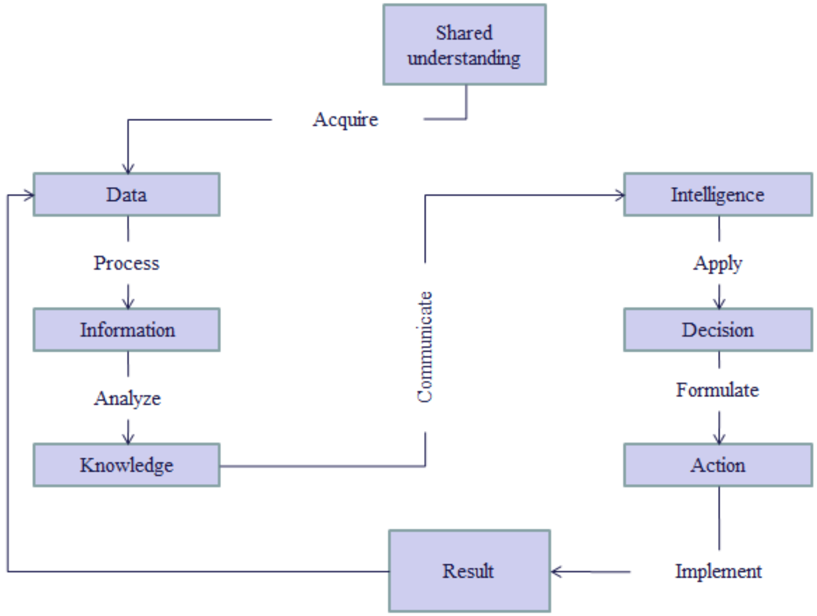

Figure 1.2. *An example of a KVC based on cognitive tasks*

Figure 1.2, from Powell [POW 01], proposes another type of KVC, which is a sequence of tasks whereby knowledge workers transform data into decisions and actions to construct the unique competitive advantage of their employer and/or social and environmental benefits. These tasks are intellectual tasks, which we call “cognitive tasks”, that successively enrich available information to act in line with the company’s objectives. Here, the value chain is not a sequence of KM processes that act on the knowledge capital of the company, but a sequence of cognitive tasks, realized by Knowledge Workers, that initially rely on the available information capital in the company to gradually give it a strategic value resulting in decision and action.

In this chapter, we will develop a KVC based on cognitive tasks. The objective is to use a chain of information transformations, to identify the cognitive tasks associated with each step and to define a transformation sequence whose management makes it possible to add value to the knowledge capital in a manner aligned with the company’s strategy.

A well-known transformation chain, partially taken up in [POW 01], exists in the domain of information management. It is the chain: data → information → knowledge → wisdom. We will examine it in the following sections and adapt it to our problem.

1.3. The DIKW model

The DIKW (Data, Information, Knowledge, Wisdom) model is one of the most famous models in the literature about information and knowledge and it is considered to be a self-evident truth. It is mostly used in information and KM, but this model remains somewhat vague and has not been discussed or verified in an in-depth way. For a history of this model and a critical study, see [ROW 07].

The most popular visual representation of DIKW is a pyramid, like the famous Maslow pyramid, with data at the base and wisdom at the peak (Figure 1.3). This representation implicitly supposes that the higher elements in the pyramid require the lower elements to be defined, and that they can be attained through the transformation of the lower elements. The DIKW model is therefore a chain where information is the result of data processing, knowledge is the result of information processing and wisdom is the result of knowledge processing.

Another visual representation of the DIKW model is a flow chart where the relationship between the components are less hierarchical, with return loops and controls, which show the complex interconnection of the transformations in the chain (Figure 1.4).

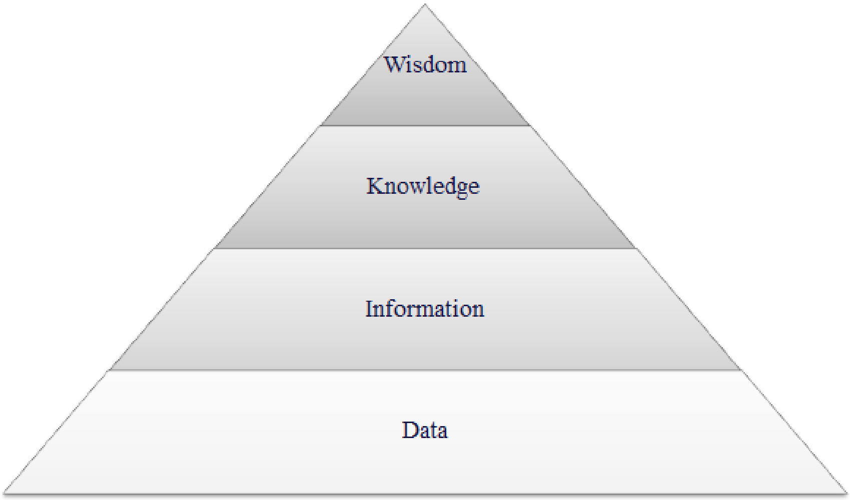

Figure 1.3. *The DIKW Pyramid*

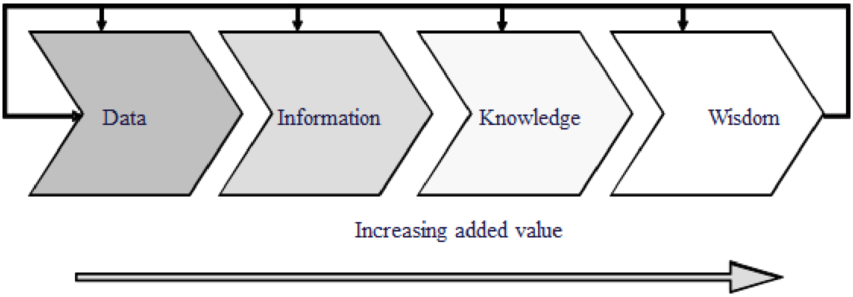

Figure 1.4. *The DIKW value chain*

There seems to be little consensus in the abundant literature (notably studied in [ROW 07]) about the DIKW model. Below, we will set out our own definitions for the different levels in order to provide a refutable framework for DIKW. In general, they reflect the usual definitions, elaborated in the references cited. This voluntary choice, which is based on classic works, is deliberate. It is reductive but necessary to avoid ambiguity and to make it possible to study the different possible transformations.

– Data

The data are defined as raw facts, and learning from the data is defined as a fact accumulation process [BIE 00]. The data are raw materials that have been gathered by people or machines through observation. According to Rowley [ROW 07], some authors ([JAS 05, CHO 05]) introduce a new element in the DIKW chain, the "signal,", which represents the reality that is perceived, selected and processed by our senses to acquire data. In fact, in semiotic theory [ECO 76], founded by Pierce [PIE 34], it is assumed that reality is always perceived as a "sign system". We define data as the perception of reality by the senses (which can be extended by observations made by machines with artificial sensors). The data are therefore the result of a perception process through a sign system.

– Information

The only unambiguous definition of information is the mathematical definition proposed by Shannon and Weaver [SHA 49]. This theory of information is a probabilistic perspective of information produced by a system. During the communication process, the receiver expects a certain message. Consider the case of a traffic light. When a person looks at a given light (the observed sign system), they already have an idea of the set of messages transmitted by this light. *A priori*, they do not know what message specifically will be transmitted to them. However, because of their experience, they expect to receive certain messages with different probabilities (red, green and yellow lights, or combinations of these colors). The quantity of information received through a set of messages (the observed sign system) is calculated as the average probability of occurrence for this set of messages, called entropy. In information theory, the introduction of the notion of entropy was a significant innovation that has been incredibly productive, even as a metaphorical tool to understand what information is.

When information is considered as a concept, this theory of information is not often mentioned. According to Nonaka-Takeuchi [NON 95], information can be viewed from two perspectives: syntactic (volume of information) and semantic (meaning of information). The syntactic perspective is based on Shannon's theory, but the semantic perspective is more important for knowledge creation because it focuses on the transfer of meaning. According to Floridi's analysis [FLO 10], during the past 10 years, a General Definition of Information (GDI) has emerged as data + meaning. A simple way to formulate a GDI, that we will use here, is a tripartite definition: information is made of data, the data are well-formed (remember that "information" comes from the Latin "in-formare", or "to give form to") and well-formed data have meaning (e.g., the data must be compatible with the meanings – the semantics – of the system in question).

– Knowledge

The most common definition of knowledge is a Justified True Belief (JTB) [CHI 82]. This means: "I know something if I believe it, if I have a proof that it is true, and if it is true". But in the perspective of KM, the definitions of knowledge are much more diverse and complex than the definitions of data or information. By summarizing all of the definitions given in the literature about the DIKW chain, Rowley [ROW 07] established that knowledge can be seen as a mix of information, comprehension, capability, experience, skills and values. Knowledge is a resource for an entity's capacity to act effectively. For example, Spender [SPE 96] considers knowledge to be data, meaning and practice. In the content of KM, there is a well-known distinction between explicit and tacit knowledge: generally, tacit knowledge is defined as internal to an individual and explicit knowledge is defined as residing in documents, databases and other recorded formats.

In [ERM 07], the authors outline an attempt at a formal theory of knowledge that is an extension of Shannon's theory of information. In this theory, knowledge has three interconnected components: information, meaning and context. Information is governed by Shannon's theory, meaning is governed by semiotic theory and context is governed by the connected graph theory. It is possible to define formal entropy that represents knowledge based on these three components. Meaning is strongly dependent on context, which can be social, professional or operational. This theory was fully developed in [ERM 00]. We will define knowledge as information (a set of messages produced by a system) that has a specific meaning in a specific context. This is detailed in Chapters 2 and 4 of this book.

– Wisdom

If the definition of knowledge is complex and contested, then the definition of wisdom is almost non-existent. Rowley [ROW 07] shows that there are very limited discussions about it in the literature related to the DIKW model. We have therefore decided to provide a definition that suits our own purposes. Wisdom is defined, in the common sense, as a "deep understanding of people, things, events and situations that confers the capacity to choose or act in order to produce optimal results with a minimum amount of time and energy". Thus, wisdom is the capacity to use knowledge optimally to establish and achieve the desired objectives. We will retain this definition while making a distinction between the individual level and the collective level.

– Individual wisdom (competence)

According to this definition, for an individual, wisdom is similar to the common notion of competence or expertise. Competence is what allows an individual to correctly complete a specific job. It includes a combination of knowledge, abilities and behaviors used to improve performance. In terms of human resources, it traditionally includes knowledge, know-how and social skills. Expertise, for its part, is a characteristic of individuals and is a consequence of the human capacity to adapt to physical and social environments. Thus, competence (or expertise) can be defined as the individual integration and transfer of knowledge and capacities in order to obtain the expected results. It is in this sense that we will define and integrate the notion of competence as "individual wisdom" in the KVC.

– Organizational wisdom (capacity)

Capacity is the ability to complete actions. According to [GRA 96], organizational capacity is the result of the integration of knowledge and complex productive team activities as well as being dependent on a company's potential to develop and integrate the knowledge of several individual specialists. It is a capacity that is specific to each company, which corresponds to the definition of "wisdom" at the collective level. This notion of organizational capacity appears in the literature in many ways and under a variety of terms: "absorptive" capacity [COH 90] (the organizational capacity to assimilate new exterior knowledge), "combinative" capability

[KOG 92] (the organizational capacity to combine existing internal knowledge), "dynamic" capability [TEE 97], core competence [PRA 90], organizational learning [HUB 91], agility [ROT 96], etc. It is in this sense that we will define and integrate the notion of capacity as "organizational wisdom" into the KVC.

1.4. KVC and management

In the previous section, the DIKW chain, adapted to the context of KM in a company, was chosen as the foundation for the definition of a KVC. It is a chain of transformation from "data → information → knowledge → competence → capacity", in which each transformation provides additional cognitive value, making it possible, based on data gathered by the company, to build meaning, then potential for action, then individual capacity and finally collective capacity. In terms of management, each transformation corresponds to a specific kind of management, the combination of which forms the management chain of the KVC. This will be explained below.

– Data management: In terms of management activity, the role of data management is to control, protect, make available and add value to a company's data. It ensures the continuous existence and quality of the organizational memory. In "cognitive" terms, data management functions as the company's memory.

– Information management: Considering the definition of information (data + meaning), the role of information management is to give meaning to data and to help workers and managers to make decisions about their tasks at different levels (operational, tactical, strategic). Information processing is crucial for decision making, as we have known for a long time [SIM 58]. Information management allows for conceptualization and provides understanding as added value for the company.

– Knowledge management: In [AVE 10], KM is viewed as a strategic management activity from the perspective of learning and growth, according to the framework of Intellectual Capital provided by Balanced Scorecards [KAP 04]: "a learning organization that is growing is an organization where KM activities are deployed and developed in order to optimize the creativity of all collaborators in a company". An internal learning process is necessary for the development and preservation of competence [NEL 91, PRA 90]. One of the conclusions of the study by Carlucci *et al*. [CAR 04] is that KM supports the organizational learning dynamic and an increase in the performance of organizational processes while also allowing a company to grow and develop its organizational competence. KM is a tool for several learning capacities including synthesizing different types of information and acquiring knowledge, abilities and new behaviors. In a company, KM facilitates the learning process of its members, who are engaged in continuous collective learning and thereby bring about the continuous transformation of the company itself. This is what is called a "learning company" [ARG 99, PED 97]. Therefore, in a KVC, the added value of KM is learning in the sense defined here.

– Competence management: Competence is knowledge in action. In the DIKW chain, Rowley [ROW 07] cites different definitions of "wisdom" that correspond to the concept of competence as effective knowledge in action. Competence reflects a large and deep capacity to understand an environment and to adapt to it by making good decisions and actions. It is the appropriate use of knowledge to improve performance (usually, we mainly consider the personal point of view, but there can be a collective aspect). This capacity is generally called "intelligence" in its etymological sense (in Latin, "intelligere" means to realize, to understand, to recognize). In this sense, in the KVC, the value added by competence is intelligence.

– Capacity management: The difference between the implementation of competence management and capacity management resides in the collective, global and organizational nature of capacity. Capacity management results in increased success for the company and general well-being. The Competence Based View and Knowledge Based View [GRA 91, SVE 01] theories consider knowledge to be a driving force for formulating and developing strategy. Capacities are therefore totally integrated into a company's goals. The benefit for the company is a general capacity for innovation, such as a global change (incremental or radical) in thought, products, process or organizations. If competence ("individual wisdom") is a superior cognitive attribute that uses knowledge, judgment and awareness, leading to an appropriate behavior [ROW 07], then capacity management corresponds to a high level of creativity in a company that innovates in an appropriate way, in relation to its commitments and its environment.

The KVC and its management are summarized in Figure 1.5. Each element in the chain corresponds to a management system used in a company. The synergy between these management systems contributes to the progression of the company in what is called "cognitive performance", which ultimately makes a company creative in the strategic sense (permanent innovation as a factor of competitive differentiation).

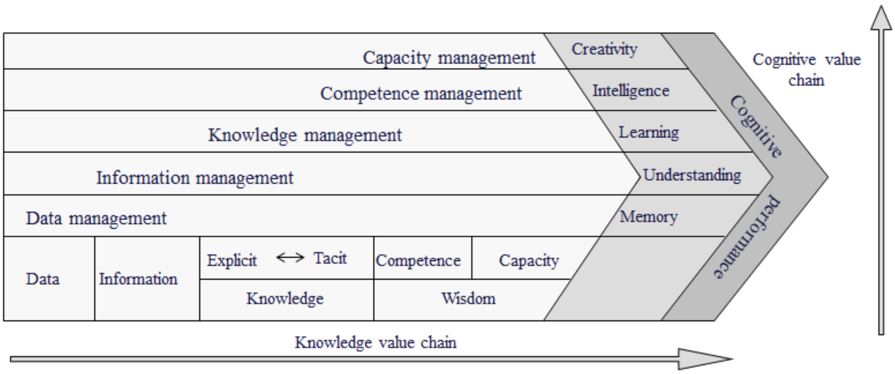

Figure 1.5. *KVC management chain*

1.5. Transformation processes in the KVC

According to Rowley [ROW 07, p. 174], if it is difficult to find a consensus about the different definitions of the concepts in the DIKW chain, then there is even less agreement about the processes that transform one concept into another in the chain.

According to [MOR 09, Chap. 4, p. 10], the transformation processes in the KVC can be divided into two categories. The first category is more tangible and objective, and can be carried out by human beings or "intelligent" machines. This type of transformation starts from reality and goes as far as explicit knowledge. For this category, the key role of information technologies is largely accepted. The second category starts from explicit knowledge and goes as far as capacity. For this category, human beings are key, and it consists of the intangible and the subjective, regarding beliefs, commitments and action. In this category, technology and information play the role of enablers, not the main elements. To describe the transformation processes in a clear and practical way, we will divide them down into three perspectives related to the definition of knowledge provided earlier:

– the “syntactic” point of view, which describes the form of the items managed by the transformation processes. This is the visible part of these processes;

– the “semantic” point of view, which describes the enablers that make it possible to construct the meaning of the processes. These enablers are filters that allow for the interpretation of activities in these processes;

– the “contextual” point of view, which describes the (cognitive) situations in which these processes take place.

This breakdown is called a “triple instrumentation” in [BRU 08] and [MOR 09]. Due to lack of space and critical studies that still need to be conducted, we will not discuss the different concepts in-depth, but we will give a few standard definitions that are generally recognized and accepted.

The point of departure for the transformations in the chain is reality, as a set of objects that possess an existence or an essence and exist independent of human consciousness.

1) *Transforming reality into data corresponds to acquiring signs (signals) through perceptive filters via observation.*

A sign is something that suggests the presence or existence of a fact, a condition or a quality. More specifically, a signal is an indicator that serves as a means of communication. It is the “semiotic assumption” that reality is communicated to us as a “sign system” [ECO 76].

The transformation process is a perception process that is the organization (in a sign system) of the unprocessed result of a stimulation of sensory receptors (which can be artificial sensors or sensory receptors like the eyes, ears, etc.).

Observation is a detailed examination of phenomena before analysis, diagnosis or interpretation. It usually involves the act of recording something, potentially with instruments.

2) *Transforming data into information corresponds to coding data through conceptual filters via a structuring activity.*

A code is a system of symbols with arbitrary meanings that are used to transmit messages [SHA 49].

The transformation process consists of constructing concepts that are formed in the mind; a thought or a notion that corresponds to a class of entities and the characteristics or essential features of this class.

Conceptualization requires a structuring posture with a mindset that is conducive to making interrelations or arrangements between parts of a complex entity.

3) *Transforming information into knowledge corresponds to building models through theories via learning.*

A model is a schematic description of a system, theory or phenomenon that accounts for its known or inferred properties and may be used for studies or subsequent actions [CAP 08].

A model is based on a theory, which is, in the common sense, a well-reasoned explanation of an aspect of the natural world; an organized system of recognized knowledge that applies in many circumstances to explain a specific set of phenomena. It is a conceptualization (an explanation) of the way the world functions.

The use of models and theories in KM can be made in the context of learning, which is, by definition, the cognitive process of acquiring knowledge (and more generally skills or information).

4) *Transforming knowledge into competence corresponds to implementing a set of practices through action via experience.*

Practice is the repeated execution of an activity with the intention of learning or perfecting a skill, action or common or normal act (often several). Economists talk about routines [LAZ 00, NEL 82] as collective competences in the form of a detailed and prescribed progression of actions to follow regularly, although they are essentially personal and tacit. They have a global formulation to achieve collective tasks, but they are only collective in the results. This codified knowledge requires an individual experience so that it can be appropriated and used by actors.

These practices are constructed step-by-step through action, which usually denotes an organized activity to accomplish an objective. Action is seen as a cognitive filter, ensuring the relevance of the lessons learned or experience feedback.

The appropriate position in this type of transformation is experience, which is a situation in which a person acquires knowledge about the world, in contrast with a position based on logic. Experience is an active participation in events or activities, allowing for the accumulation of knowledge or skill.

5) *Transforming competence into capacity corresponds to constructing a KM strategy with strategic filters (alignment) via a vision.*

A strategy is a specific long-term plan for success.

Alignment, which is a coordination (correct or desired) of components, is the appropriate tool to integrate or harmonize objectives, practices, etc., in a company.

The capacity to build a strategy involving a company's knowledge aligned with the company's strategy requires a vision, seen as an exceptional competence of discernment or perception, an intelligent anticipation. The term "vision", especially for future developments, has a certain religious or spiritual connotation, but that is where the similarity with KM stops.

This analysis, summarized in Figure 1.6, gives us the tools (signs, codes, models, practices, strategy), the cognitive activities (perception, conceptualization, theorization, action, strategic alignment) and the attitudes (observation, structuring, learning, experience, vision) to implement in order to manage the KVC.

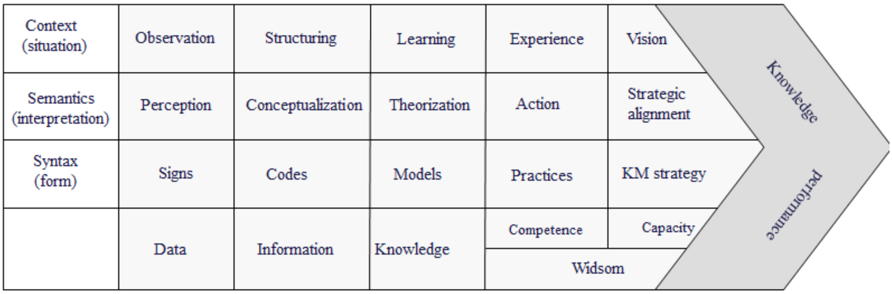

Figure 1.6. *Transformation processes in the KVC*

1.6. Practical application

To use the KVC in a company, the French Knowledge Management Club (*Club Gestion des Connaissances*)[1] created a value analysis tool called KMAV (*KM Added Value*)[2] where the challenge is to make the value added by KM intelligible for managers and raise awareness with the actors concerned by this project.

This tool is an analytical framework that includes 21 criteria corresponding to different transformations of levels in the KVC from data to capacities (Figure 1.7).

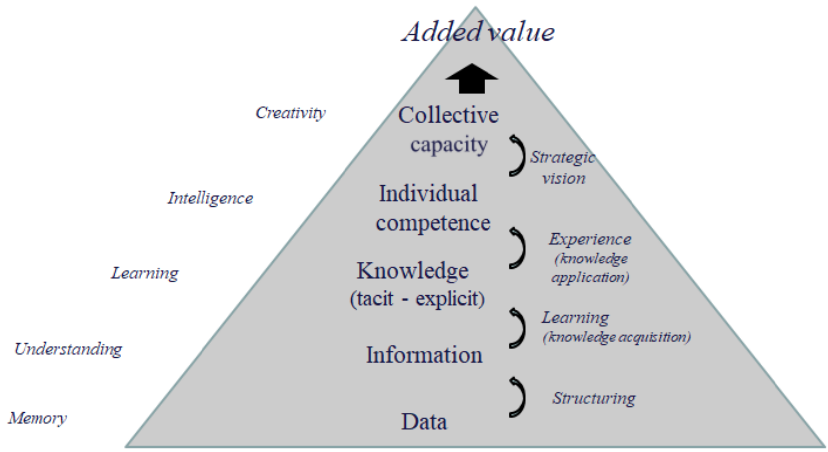

Figure 1.7. *The knowledge pyramid, a support for the KMAV tool*

Each criterion corresponds to a question to ask the respondents. Here are a few examples:

– From data to information

Criterion 2: Do we have a semantics for interpreting data?

1 http://www.club-gc.asso.fr/.

2 Creative Commons licence (CC-BY-NC-SA), *Club Gestion des Connaissances*, 2016–2017.

– From information to knowledge

Criterion 6: Is there a model allowing us to structure and contextualize information?

– From knowledge to competence

Criterion 15: Is knowledge used in practice? Is its effectiveness measured?

– From knowledge to capacity

Criterion 21: Does the top management control the implementation and correct functioning of collective capacities related to strategic objectives?

Each criterion is evaluated on a scale of 1–4, corresponding to the levels of increasing added value. For example, for criterion 2: "Do we have a semantics for interpreting data?" four answers are possible:

– Level 1: *It did not seem necessary to establish a shared semantics*. The project did not raise the question of data semantics. These cases are often compartmentalized projects: projects where tacit knowledge is strong or projects conducted without user involvement.

– Level 2: *A semantic exists but was imposed without explanation*. The project adopted the semantics of a software, a standard, etc., without ensuring that it was suitable and that it was adapted for the profession. It could be a software package imposed on a profession without really corresponding to the way things are done. Data can be distorted or even become insignificant.

– Level 3: *A first draft of a semantics was developed*. The project has started to establish or adopt a standard, a glossary with the meaning of different data and their context. This glossary has not yet been shared or related to all of the data.

– Level 4: *There is a clear and defined data semantics*. The data are standardized based on an external norm or one that was constructed internally. This standard makes it possible to make all of the data coherent and homogenous.

The process of implementing the framework in a company occurs in three steps:

– identifying the elements that make up the levels of added value. Based on the definition of the scope and the challenges, this consists of identifying the collective capacities associated with the challenges, the competence required, the knowledge underlying the competence, the information and the corresponding data, all while gathering the action proposals that emerge from the surveyed group;

– evaluating the value added in the current model. This is the goal of the audit conducted with the relevant groups;

– elaborating actions with high added value in the very short term (quick wins), medium term and long term.

Value levels	Criteria
From data to information	– Availability and quality of data – Data semantics – Data processing method – Data development potential
From information to knowledge	– Process of making necessary information available – Model providing modes of interpreting information – Frame of reference for understanding information – Efficiency of modes of interpreting information – Appropriation of modes of interpreting information – Capitalization in real time
From knowledge to competence	– Experience feedback – Integration of knowledge in the processes – Experience of application – Renewing competences on a life-cycle basis – Application of knowledge – Updating competences based on the evolution of knowledge
From competence to capacity	– Strategic vision – Integration of individual competences into collective capacities – Collaboration between individual competences – Actor mobilization factors – Evaluation of collective capacities

Table 1.1. *Analytical framework of a knowledge value chain*

These large steps involve the hierarchy, knowledge managers and operational managers. The communication plan accompanying the implementation is very important.

The analysis, conducted on the entire company or on a specific unit, can be presented simply with a clear graphic representation illustrated on the knowledge pyramid (Figure 1.7) and is a very useful support for what follows. The results of the analysis are presented and discussed in a top management committee to decide on actions that contribute to the continued progress of the company.

This tool has already been successfully tested in multinational companies, sometimes on a set of units in several countries. This method caused the interviewees to reflect, which developed their way of understanding KM. They made proposals, even after the audit interviews. The approach improved relations between collaborators. The re-establishment of work groups allowed them to see that they had contributed to a development. Incidentally, the managers also learned a lot.

1.7. Conclusion

This chapter proposed a KVC that takes into account the individual and collective nature of knowledge in a company. It is a chain of continuous transformation that starts from the perception of reality through the data until it reaches an organizational wisdom that reflects a company's creative maturity. KVC management gradually steers the company toward greater cognitive capacities, from memory to creativity. Operationally, processing the KVC occurs through gradual transformation processes from a company's data all the way to its strategy.

The contribution of this chapter is that it provides, in the strict framework of KM theories, a KVC that is internal to the company based on a sequence of cognitive tasks regarding information manipulation. An overview of some foundational ideas in information sciences made it possible to isolate and specify the characteristics of these tasks that could provide tools to work on this value chain.

This analytical framework of the value of knowledge can provide, as has been demonstrated, operational management tools.

2

The Knowledge Capital of a Company

2.1. Introduction

2.1.1. *The accumulation of knowledge*

KM raises new problems, which were revealed by the new discipline called the "knowledge economy" [FOR 00]. Indeed, knowledge is a very strange thing. It has three basic properties as an economic good.

– *Knowledge is a good that is difficult to control and that creates externalities*

This means that a company has much more difficulty controlling its knowledge than its machines. There are two fundamental risks [COH 06]: *spill-over*, which is the involuntary communication of knowledge, and conversely *lock-in*, which is an exclusive knowledge sharing relationship that prevents actors from accessing exterior knowledge. Spill-over is constant; knowledge continuously escapes from companies (if only through the marketing of their products). This knowledge can benefit competitors without recompense. These are called "positive externalities" (as opposed to patents, for example).

– *Knowledge is a non-rival good*

Unlike tangible goods, as a resource, knowledge is inexhaustible because it is not destroyed through use. Agents who use the same piece of knowledge are therefore "not rivals". An agent can use a piece of knowledge an unlimited number of times and an unlimited number of agents can use the

Knowledge Management: The Creative Loop, First Edition. Jean-Louis Ermine.

same piece of knowledge. This means that transmitting knowledge is a positive sum game: it only increases the number of holders.

– *Knowledge is a cumulative good*

Knowledge is the main element that makes it possible to create new knowledge. This means that knowledge accumulates and this accumulation is a factor in collective progress, especially for a company.

One of the lessons of the knowledge economy is to manage knowledge as a company asset. In the production process (of goods or services), knowledge is called a "joint product". The production of knowledge in a company occurs "by chance" (but we know there is no such thing as real chance), while the community in question is focused on other goals. In a company, knowledge and know-how are not produced deliberately. It is a complex process related to learning, especially learning by doing. This process, as already mentioned, is cumulative: knowledge should not be viewed (as it often is) as a volatile flow, but rather as capital that accumulates in a company, which we will call "knowledge capital". While filling the production mandates that characterize it, a company produces, in a "joint" and unintentional (even free!) way, a new wealth that accumulates in the company. This new wealth raises all kinds of questions because currently, we do not know how this wealth is reinvested in the production loop. It is the acceptance of the fact that knowledge forms a capital that accumulates in a company that is the basis here for the whole question of KM.

2.1.2. *The company as knowledge producer*

This chapter is based on the principle that a company (or an organization in general) has an "organizational knowledge" that is unique to it. This knowledge is much more than the sum of the individual knowledge of employees, and it is more or less maintained over time through information products (documents, databases, software, etc.) or individual and/or collective exchanges/transfers. It accumulates in a company over the course of its history and forms the "knowledge capital". The existence of this capital as an (intangible) subsystem of a company is still controversial because it challenges the classic perspective, which equates a company to a system that processes information for operational and decision-making actors. This new vision of a company as a "knowledge producer" will be explored in this chapter.

The focus of the model proposed in this chapter is to establish the flow of knowledge, which is a product that is specific to a company but which does not appear as such in traditional models. The knowledge capital is a "repository" where this knowledge accumulates. The subsystem of knowledge is clearly an active system. Traditionally, this translates into flows that create active interrelations with other subsystems in the company. These flows can be divided into two categories. Flows that move from other subsystems toward the subsystem of knowledge correspond to the enrichment (over time) of a company's knowledge capital through its different human actors or components (physical objects, information systems, etc.). Flows in the inverse direction correspond to the implicit (most often) or explicit appropriation of this capital in order to use it in the company's production objective.

Although it is natural, the conceptual separation between the knowledge capital of a company and its other subsystems is not common in the usual approaches to KM. Most of the time, these approaches focus on the three classic aspects of a company: process, people and technology.

It is a bit challenging to introduce the knowledge aspect for the KM approach here. In this chapter, we will start to develop the cornerstone of this whole book, namely a KM approach that is knowledge based, which might appear tautological at first, but it is nevertheless not a common approach. In fact, most existing KM approaches are generally not directly oriented by knowledge. As noted, they are most often people-oriented, technology-oriented, or process-oriented, and all of these perspectives can also be conflated. Therefore, we are presenting a new way to consider KM here.

2.2. Modeling a company as a knowledge producer

2.2.1. *Systemic modeling*

The general system theory [BER 68], popularized in France by the works of Jean-Louis Le Moigne [LEM 77, LEM 90], constitutes a break with the traditional approach to analysis and modeling resulting from the current limitations of the analytical method, advocated in science since Descartes.

This is due to the fact that current problems are essentially related to complex systems, in a manner that is now widespread. Complex thought, championed by Edgar Morin [MOR 90], is now standard and can be applied to the theory of knowledge through his work *La connaissance de la connaissance* [MOR 86]. The systemic method, which is intended to be complementary to the analytical method, can contribute some elements to the issue of complex thought. The systemic perspective effectively strives to provide modeling tools that make it possible not to explicitly present structures, but to identify an intelligibility that makes it possible to understand the system under consideration in its entirety. The intelligibility does not distort the vision of the systems, while preserving the complexity.

In general system theory, a company (or any system) can be modeled with different levels of detail that do not reflect the same vision of the company. We will show how we can provide a systemic model of a company by progressively summarizing the different levels of interpretation.

2.2.2. *The "black box" model*

This is the simplest model that reflects a company that is active in its environment (a system that does not exchange with its environment is an inactive system).

The company is seen as a "flow processor". It receives incoming flows (input) and produces outgoing flows (output). In general, three types of flow are distinguished: energy, material and information, but this can be expanded as needed (financial flow, cognitive flow, etc.), if it has a direction.

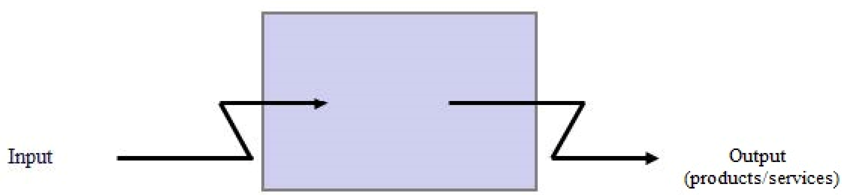

Figure 2.1. *The company seen as a black box*

The company is seen as a producer of a good or a service, materialized by its outgoing flow and by its transformation of the incoming flow.

This is the simplest view that we can give of a company without rendering visible any of the subsystems that are involved in the transformation process.

2.2.3. *The "division of labor" model*

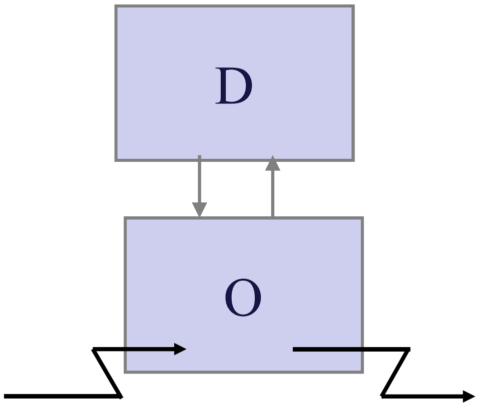

Figure 2.2. *A Taylorian model of a company*

More in keeping with industrial companies of the last century, this model considers two subsystems within a company that organize the production system: the decision system D that designs and directs the production system, and the operating system O that completes the flow transformation process. This is the classical model of the "division of labor" that separates the design of tasks and their supervision from their operational execution. This Taylorian business model was foundational for the Industrial Revolution. The two systems, O and D, are connected through information flows.

2.2.4. *The informational model*

With the complexification of companies and their production facilities, it quickly appeared that information flows between the decision system and the operating system had to be managed in an increasingly sophisticated and efficient manner. This gave rise to the concept of the information system.

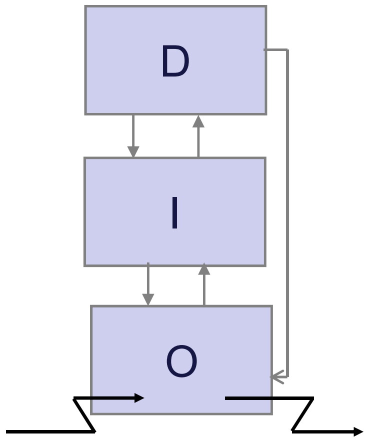

Figure 2.3. *The model of a company integrating the information flow (OID model)*

The information system records the representations – in a symbolic form – of the operating system's operations (the behavior of the complex system), saves them and makes them available, generally in an interactive form, to the decision-making system [LEM 77, LEM 90] (there is also feedback from the decision system toward the information system). This model is very commonly employed in companies: the operating system is made up of actors who transform the flows, energy, materials or information into other flows of the same kind; this is the company's process itself. The information system is composed of everything that stores, saves and makes available the information: documents, databases, texts, images, etc. This information system informs the company's decision makers who can act on the production process through the operating system. For more than 50 years, this system has been considered to be a system in its own right in a company, related to a dedicated strategy, management, company and technology. The dominant model of a company, which is the base of all of the work conducted about information systems, is now the OID model (Operation, Information, Decision), with all of the global information flows that must be considered.

2.2.5. *The knowledge capital model*

From a KM perspective, this model has evolved somewhat [ERM 00]. Knowledge is not an attribute that is specific to one of the subsystems, but it exists independently as it is, like capital that is specific to the system. This justifies the hypothesis of the existence of a fourth subsystem that we will call the "knowledge system" or "knowledge capital" to recall Umberto Eco, where the expression first appeared [ECO 72]. This subsystem is an active system. It has two essential activities borrowed from Edgar Morin [MOR 86]: the *activity of acquisition* of knowledge that is produced, and the *activity of cognition*, concerning the transmission of this knowledge. The subsystem of knowledge is seen as an active subsystem of the system. This process is traditionally represented by flows that create active interrelations with other subsystems of the system. These flows can be divided into two categories: flows that move from other subsystems toward the subsystem of knowledge correspond to activities of *competence* (knowledge production) according to Edgar Morin's designation, and flows that move from the knowledge system toward other subsystems correspond to activities of *cognition*. We also designate competence and cognition flows as cognitive flows. Competence flows correspond to the enrichment (over time) of the system's knowledge capital through its different human actors or its components (physical objects, information systems, etc.). Cognition flows correspond to the implicit (most often) or explicit appropriation of this capital in order to use it in the system's specific transformation process.

The knowledge capital that we want to manage is most often a subset of all the knowledge produced and used in a company. Its identification is not *a priori* obvious and does not always correspond to our intuitive idea of it. If, for example, after producing an artifact, a company's service wants to manage the knowledge involved in its production process, then the reference system is not the service itself, as we might imagine in a superficial analysis. In fact, it includes components that are internal or external to the company that participate in the knowledge set concerning the production in question. This can range from a company that conducts market studies to official national or international organizations that enact the necessary laws or regulations to be considered in the production. The identification of all these components is necessary to outline the knowledge corpus that we want to manage (in the example here: market knowledge, legal and regulatory knowledge, etc.).

The knowledge capital model is an extension of the OID model, to which we add a fourth subsystem K (knowledge) and the flows connecting it to the other subsystems (cognitive flows of competence and appropriation).

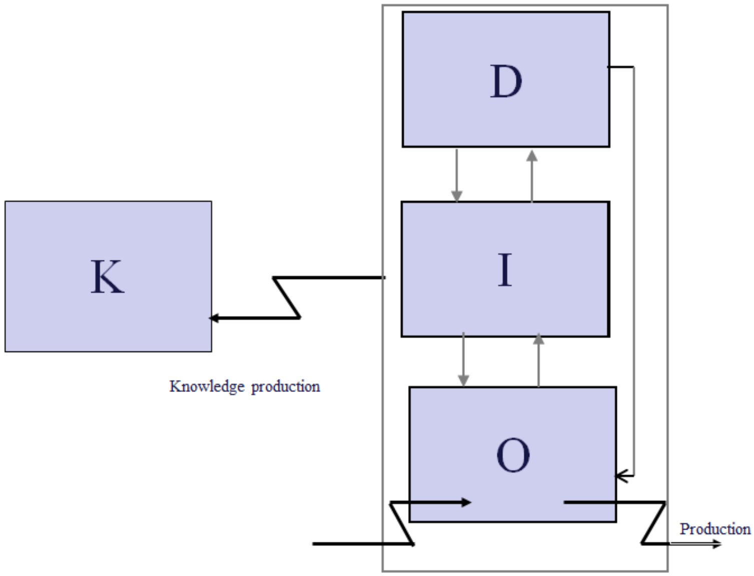

Figure 2.4. *The model of a company that integrates knowledge flows*

It is clear that each of the three subsystems, O, I and D, have their own knowledge. The operating system has the operator's know-how, expert knowledge, knowledge of processes and instrumentations, etc. The decision system has its knowledge of the exterior environment, its organizational capacity, etc. The information system possesses the considerable sum of knowledge that is "latent" in documents, databases, etc. This knowledge is indexed in the company's knowledge capital, which is actively interrelated with the three subsystems. In one sense, the knowledge capital of the company is enriched (over time) through its different human actors or its components (physical objects, information systems, etc.). In the other sense, the actors implicitly (most often) or explicitly appropriate this capital in order to use it in the system's specific transformation process.

The focus of this model is to establish the flow of knowledge, which is a product that is specific to a company (called "joint" according to the dedicated economic term), but that does not appear as such, which seems to be a weakness in light of the strategic importance of knowledge. The knowledge capital thus appears as a "repository" where this knowledge accumulates.

2.2.6. *The knowledge capital and knowledge actors model*

The term *knowledge worker* (or knowledge actor) is not a new notion, because it was coined in 1959 by Peter Drucker [DRU 59]. Since then, a lot of questions have been raised about the status of the knowledge actor, even predicting that soon all actors would be knowledge actors. This term designates any person who works on tasks in which knowledge is developed or used. Examples of this kind of task include planning, acquisition, analysis, organization, programming, distribution, marketing and anything that contributes to the transformation or distribution of information. Of course, this concerns the fields of information technologies, such as information systems, technical writers and researchers, but it extends far beyond these boundaries. If we understand the knowledge actor as someone who creates, applies, transfers and/or acquires knowledge, then anyone and everyone could be implicated. The problem is more about establishing conditions to improve this work in a given strategic context through the identification and development of capacities, motivations and opportunities, than about identifying who is completing these tasks.

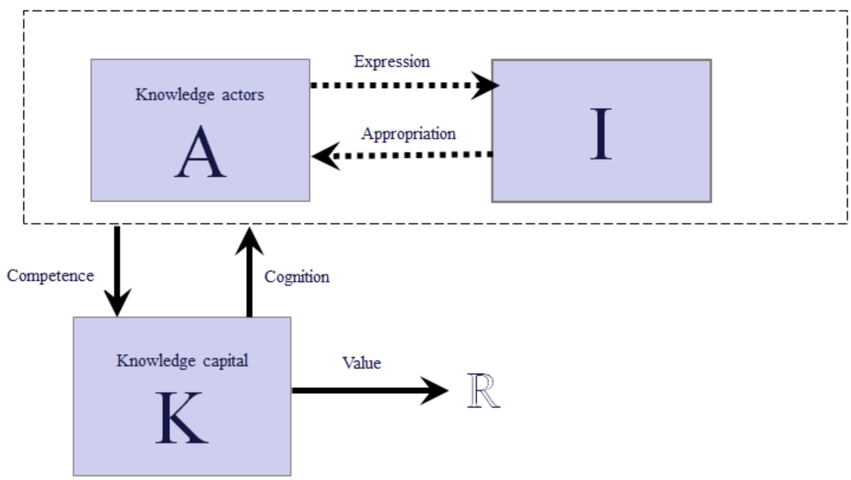

Figure 2.5. *A company model including knowledge capital and knowledge actors (AIK model)*

In KM, knowledge is very often considered to be closely related to the individual (think about so-called tacit knowledge, which is not always able to be expressed, compiled in individuals' minds), and does not exist without the person. It is also related to groups of individuals and communities of knowledge (like communities of practice [COP]). KM is often conflated with the management of knowledge actors, even if this is only part of the problem. The role of the actor networks is therefore significant, more than the decision-making or operational role of the individual, even more so because in complex and advanced companies, decisions and operations are often shared by the same actor networks. In the OID model, we can consider that the elements of the Operating and Decision systems are grouped in actor networks, with these networks providing added value to the company with their know-how in the decision-making or operational processes. This cognitive capacity of actors is supported by the information system, in direct relation with the actors who appropriate the information to transform it into operational or decision-making knowledge. Conversely, the actors produce information that accumulates in the information system when they formalize their knowledge and they express it in the information system.

The final business model proposed here, called AIK, is the most appropriate for KM. It is formed by subsystems of information (I), knowledge capital (K) and knowledge actor networks (or knowledge communities) (A). Subsystem A is related to I by information flows that translate the expression of actors when they formalize their knowledge as well as the appropriation of information by actors, which is useful for creating operational or decision-making knowledge. To connect it to the subsystems O and D that are disappearing from the model, there is a natural inclusion of these systems in A because in the company's flow transformation process, an actor necessarily produces a decision or an action (KM in a company is only interested in managing this type of knowledge). Knowledge can be produced directly by the actors or by interaction with the information system. Knowledge flows are therefore not specific to I or A, but to the system formed by the set of I and A.

It should be noted that it is not only knowledge actors who manage competence or cognition, contrary to popular belief. A technical device, a document or an information database all intrinsically bear knowledge (that sometimes requires a lot of effort to extract, such as a historian discussing the architectures of civilizations that have disappeared) and create competence in knowledge capital. This is not explicitly represented in the model (which does not exclude it, because it is implicitly included in the set (A, I)). However, such a type of buried knowledge will only produce value for a company if it encounters an actor network.

This notion of value production is fundamental in KM. It is simply represented in the model by a value function that starts from knowledge capital toward a set of real numbers R. If this representation is simple, however, defining such a function is not simple at all. There can – there must – exist several different functions according to the different issues addressed (strategic, economic, technical, etc.). The notion of the financial or book value of knowledge capital is probably the most often addressed, but other notions of value can be defined, and we will see some of them in this book (like knowledge criticality value).

In conclusion, we will define KM as the management of a system where actor networks interact with an information system (through the functions of appropriation and expression). This system produces and consumes knowledge (though the functions of competence and cognition). This knowledge accumulates in the company's knowledge capital. The knowledge is assessed by a value function. Such a system provides added value to the knowledge, which is to say that the knowledge produced has a greater value than the knowledge consumed.[1]

2.2.7. *Integration of customer knowledge and external knowledge into the AIK model*

To account for a company's environment, we will introduce two new subsystems that we will call M for market and E for environment (informational environment) [ERM 08].

Enhanced in this way, the model (MAIKE model, Figure 2.6) accounts for all of the systems interacting in a KM perspective:

– knowledge actors, grouped in knowledge communities, who share and create knowledge (A);

– an information system that stores, processes and makes a company's information (I) available;

– the knowledge capital, where knowledge created and used in a company accumulates (K);

1 More specifically, when knowledge is used (by the cognition function), the knowledge that it produces in return in the knowledge capital (by the competence function) has a greater value.

– the environment that contains essential information that must be transformed into useful knowledge for a company (E);

– the market (customers), whose knowledge is essential for a company's operation (M).

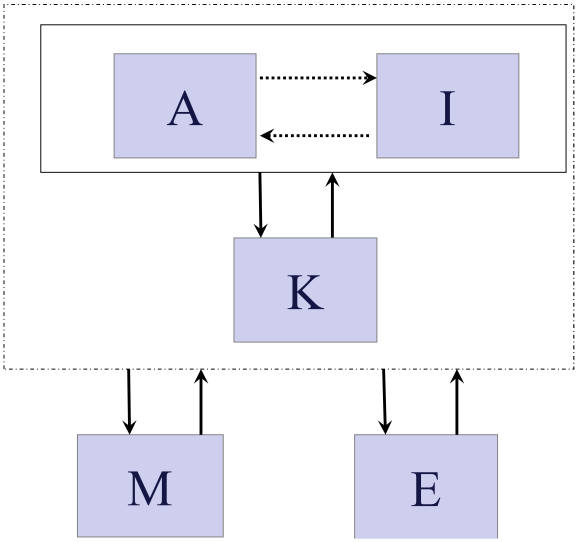

Figure 2.6. *The model of a company and its environment*

Now, the next step is to examine these two new systems, M and E, as well as the flows they exchange and transform in conjunction with the company:

– the E system and its interactions are a known problem regarding the relationships between environmental scanning activities, business intelligence and KM activities;

– the M system and its interactions are currently the subject of a great deal of attention because of new knowledge tools that marketing has access to, such as databases hosted and managed in data warehouses, creating other activities such as data mining. The combination of these two types of tools is set out in Customer Relationship Management to try to create a competitive advantage in a very competitive market. Customer knowledge appears to be a system that is developed from the interaction of company actors, the market and the information system. It is an autonomous system that it is important to understand and structure to create true Customer Knowledge Management, a source of innovation for marketing;

– for an approach to the systems E and M and their interactions, consult Chapters 5 and 6 of [ERM 08].

2.3. The operators of the AIK model

An operator is an internal composition law between elements in the same subsystem. The most common knowledge management theories give us three operators for each of the subsystems in the AIK model.

2.3.1. *The Wenger operator*

This operator is internal to the system of actor networks, A. We note as $\otimes_W$ the operator that we call the Wenger operator, in reference to the seminal works of Etienne Wenger about COP [WEN 98].

It is an operator of aggregation between actors, or between actor networks, to form networks or communities of knowledge that produce knowledge (with added value). The conditions of this grouping of actors are not explicit and can be complex (see Wenger's three conditions for COP: shared repertoire, joint enterprise, mutual engagement). This is a formalism for noting the fundamental operation to consider in KM in the system of knowledge actor networks.

2.3.2. *The Nonaka operators*

2.3.2.1. *Summary of the Nonaka–Takeuchi theory*

We are referring here to the famous theory of Nonaka and Takeuchi [NON 95] that strongly influenced all current KM research and approaches. This theory distinguishes two types of knowledge: explicit knowledge and tacit knowledge. Explicit knowledge is able to be directly understood and expressed by every individual in a company. Tacit knowledge is specific to each individual. It is formed by personal know-how and individual beliefs and aspirations. According to this theory, there are four modes of conversion between tacit and explicit knowledge (designated by the acronym SECI):

– *socialization*, tacit to tacit (sharing in the work place, apprenticeship);

– *externalization*, tacit to explicit (metaphors, concepts, hypotheses, models, analogies, transcription, etc.);

– *combination*, explicit to explicit;

– *internalization*, explicit to tacit, where explicit knowledge disseminated in a company is assimilated by individuals who benefit from new knowledge.

Using this theory, we can easily describe the process of knowledge circulation in a company, which is sometimes called the "virtuous circle of knowledge", summarized in Figure 2.7.

The knowledge transfer process can occur in two ways:

– a direct transfer, through socialization, to use the expression of Nonaka–Takeuchi. This consists of the communication of knowledge that occurs without elicitation. The prime example of this kind of process is mentoring, where learning occurs through direct contact with the expert, through observation and "osmosis". Other tacit knowledge transfer methods rely on knowledge actor networks, notably COP or community of interest networks (COIN), professional groups, etc.;

– an indirect transfer, which can be a partial alternative to direct transfer. This process can be divided into three subprocesses:

- the first subprocess (externalization) is elicitation. It consists of revealing a part of the tacit knowledge (collective or individual) in a visible informational form. Elicitation of this knowledge can never be complete, because it will always be limited by the "tacit barrier". However, a large number of methods and tools are already available for this task. The first type of approach stems from what we will call knowledge transcription: some tacit knowledge can be made explicit simply by transcribing it in a more or less structured way. A second type of approach arises from what we call knowledge modeling: some tacit knowledge can be made explicit using modeling tools. Modeling is a process that can be fairly cumbersome to implement, but it is very powerful compared to simple transcription. This is often called knowledge engineering;

- the second subprocess (combination) involves the circulation and sharing of information which allows for researching and recombining information. Information technologies (notably the intranet) are powerful sharing tools with considerable gains for collective capital (but this is not a sufficient condition);

- the third subprocess (internalization) is that of appropriation. An explicit piece of knowledge is only of value when it is used in action (which is called "actionable knowledge"), namely when applied to a context that contributes to achieving the company's goals. For this, people must recreate, from shared explicit knowledge, their own tacit knowledge that will serve them in a specific way in their work. Experimentation (personal or collective) and training are the classic examples of this process.

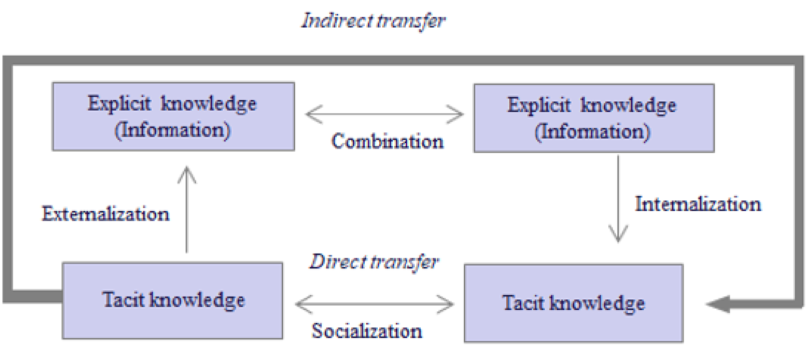

Figure 2.7. *The process of knowledge circulation in a company according to Nonaka*

2.3.3. *Integration of the Nonaka theory into the AIK model*

The two fundamental operators defined by Nonaka are integrated into the AIK model.

– *The combination operator*

This operator is internal to the information system I. This operator represents the combination of information that an actor or a piece of software can achieve in an information system. It is noted as $\otimes_c$.

– *The socialization operator*

This operator is internal to the knowledge capital K. This operator represents the combination of knowledge through knowledge actor networks. It is noted as $\otimes_s$.

The formalism of the operators makes it possible to represent simply certain elements that we attribute to a system where knowledge is managed.

Thus, the fact that two actors in a knowledge community create competence by combining their knowledge, in the sense of socialization, is written formally as:

$$\text{Competence }(a \otimes_w a') = \text{competence}(a) \otimes_s \text{competence }(a')$$

The cognition function does not have such a property: the appropriation of knowledge in a knowledge community does not correspond to the combination of knowledge that the actors appropriated individually (according to the systemic principle "the whole is more than the sum of its parts").

Similarly, the fact that the combination of information (that is in Nonaka's theory, explicit knowledge) corresponds to the elicitation of knowledge shared by actors in a community is written formally as:

$$\text{Expression }(a \otimes_w a') = \text{expression}(a) \otimes_c \text{expression}(a')$$

The appropriation function does not have such a property. It is also difficult to see how a collective appropriation is combined based on the appropriations of each actor.

The other notions developed in Nonaka's theory integrate naturally into the AIK model.

– *The externalization function*

This function represents a flow between K and I.

The externalization function represents the conversion of knowledge into information.

– *The internalization function*

This function represents a flow between I and K.

The internalization function represents the conversion of information into knowledge.

The complete AIK model

Figure 2.8 graphically represents the complete AIK model of a company from a KM perspective, as we have just defined it.

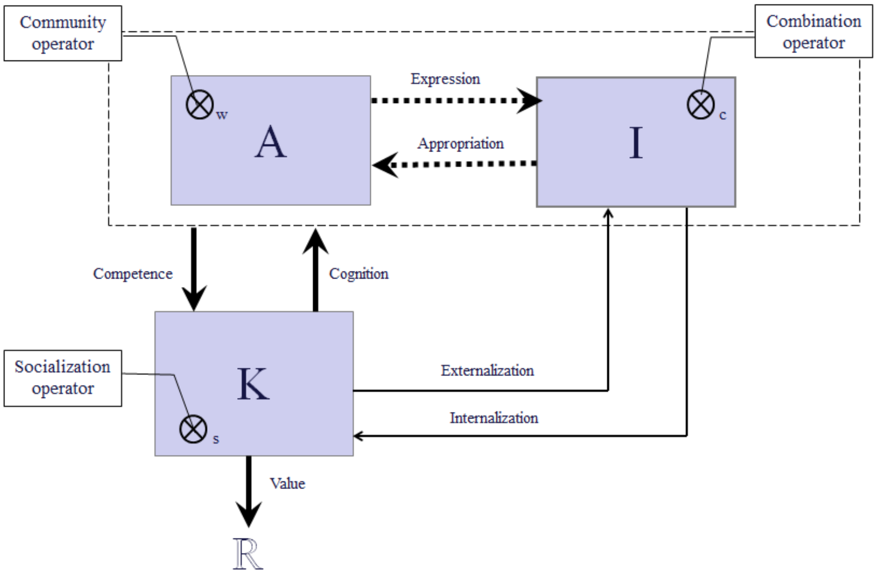

Figure 2.8. *The complete AIK model*

The formal model presented here is a simplified form of a mathematical model that is more sophisticated but more difficult to appropriate [ERM 05].

2.4. Tacit/explicit knowledge and knowledge communities

The theory of knowledge communities (see [WEN 98, COH 06]) does not discuss knowledge properly speaking, but rather the interplay of actors and their modes of organization and operation. In KM, the applications of these concepts make extensive use of structures included in information systems. It is therefore an "indirect" management of knowledge that occurs like this through the interactions between knowledge actors and information systems.

The relationship between the theories of communities and tacit knowledge, although it may seem intuitive, is rarely addressed. The model proposed here provides a relationship that is easily formalized and proves to be a strong and well-founded connection. There is a formal relationship between externalization and expression, internalization and appropriation (which does not mean that all aspects are equivalent). The relationship is relevant and interesting if the use of the information system by the knowledge actors still allows the KM System to produce added value on knowledge. Intuitively, this seems very natural.

The connection established between the two theories makes it possible to act, with the same theoretical base, either in the framework of the communities in interaction with the information system or directly on the knowledge capital. The first option seems (*a priori*!) more "operational", while the second option seems more difficult to operationalize with a knowledge capital that is partly invisible.

The relation between the approaches of tacit/implicit knowledge and knowledge communities is illustrated in Figure 2.9.

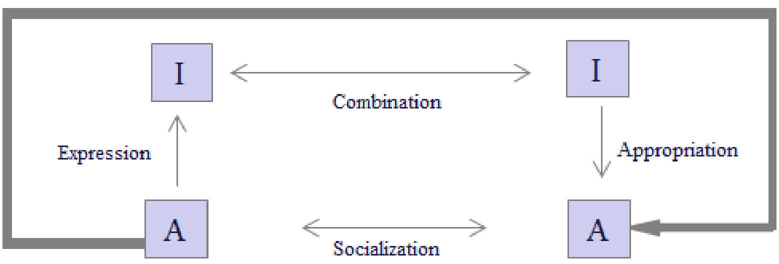

Figure 2.9. *The knowledge transfer process in knowledge communities*

We can relate Figure 2.7 of the SECI process with the diagram of the AIK model (diagram of knowledge transfer in knowledge communities) in Figure 2.9.

The knowledge transfer here can occur directly, by exchanging tacit knowledge, or indirectly, through the succession of the processes of expression, combination and appropriation.

We can see that Figures 2.7 and 2.9 are formally very similar. The problem is knowing how they are equivalent. Concretely, this means knowing how managing knowledge in a company is similar to managing the knowledge communities in that company, while providing them with the appropriate information tools. Although the connection seems intuitively obvious, the problem is vast and open.

2.5. Mapping as a modeling tool to steer the AIK system

The construction of the previously-mentioned models corresponds to the systemic method, which, according to Le Moigne:

> "does not break up but articulates systems, which does not seek structures but organizations, which does not seek evidences capable of explaining, but relevant things that make it possible to understand. [These models] allow for a global vision (systemic and non-analytical), that engages relevant points of view permitting the understanding of the system studied" [LEM 90].

Thus, a model makes it possible to have a coherent vision of the different points of view that account for the complexity of the system studied, and provides tools that are intended to control them. One very common method to model the subsystems (A, I, K, O, D notably) is the mapping method.

Mapping is a process of abstraction that involves selection, classification, simplification and symbolization. Geographical mapping is the most well known. Geographical maps have been a rich source for creating metaphors intended for understanding systems [CHE 03]. Mapping proposes graphic languages that are very powerful tools for representing systems, communicating between actors, understanding direction, etc.

In the systems described, the mapping modeling tools have often been around for a long time and are commonly used in companies:

– one of the most well-known mapping tools concerns the operating system O. It is called process mapping or Business Process Modeling. It is a standardized graphic notation to model business procedures or processes and it is maintained by the Object Management Group;

– one of the most well-known mapping modeling methods concerns the information system I. Mapping an information system not only concerns the computer system, but also the strategic, professional, functional and organizational dimensions. It is intended to represent a structured set of all of the elements that contribute to information management in a company, whether it is computerized or not, in totality or in part. This map is most often used to represent the architecture of a computer system;

– for the system of actors A, social network analysis software makes it possible to represent actor networks with their connections in very diverse ways and provide maps of actor networks in companies;

– for the decision system D, when it consists of a company's strategic decision system, it can be modeled by "strategic maps" [KAP 04];

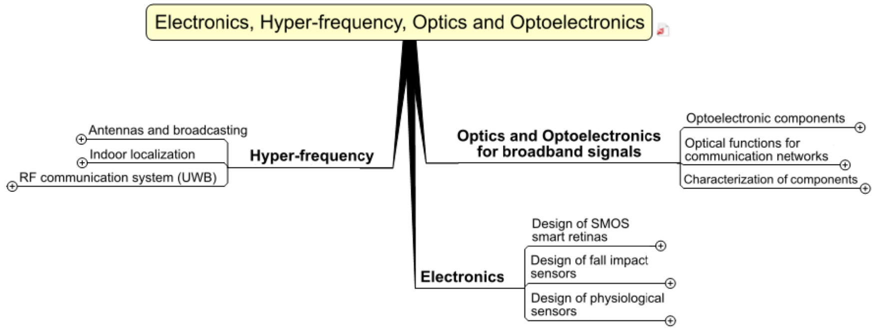

Figure 2.10. *Knowledge capital in an electronic domain*

– the knowledge system K falls under "knowledge maps". According to [SPE 99], "Knowledge mapping is defined as the process, methods and tools for analyzing knowledge areas in order to discover features or meaning and to visualize them in a comprehensive, transparent form such that the business-relevant features are clearly highlighted". Knowledge maps are designed by transferring certain attributes of tacit or explicit knowledge in a graphic form that is easily understandable by the end users (managers, experts, engineers, etc.). A knowledge map is an identification of the knowledge capital. It is a structured representation in the form of a classification of a company's knowledge capital (see Figure 2.10). The elements of this classification are "knowledge domains". Establishing such a classification and defining what a knowledge domain is in practice is not an easy thing.

"Strategic maps" and "knowledge maps" will be elaborated later on in this book. It is also possible to consult Chapter 4 of [ERM 08].

2.6. Practical application

Companies often need to make their knowledge capital visible to determine KM actions. The adage "we don't know what we know" is especially valid for companies, which often do not have a very precise idea of the knowledge and know-how that they possess to maximize their activity. The identification of their knowledge capital, even partially for a particular activity, can prove to be precious.

The model described in this chapter is a useful tool to achieve a reasoned and systematic identification of the knowledge capital (of a part, in general) of a company.

To that end, the MASK method (see Chapter 7 in [ERM 08], for example) proposes a simple analysis to achieve such a task.

– The first step is to define the global system (that possesses the knowledge capital to study) by the following elements:

- Purpose: Mission assigned to the system studied. For example, what is the practice that you want to describe in your activity?

- Input flow: Input of the system to study that is transformed based on the objective of the system. For example, what are the elements that are necessary for the implementation and achievement of the practice?

- Output flow: Output of the system to study, produced by the transformation of input flows, according to the objective of the system. For example, what are the elements produced as a result of the practice?

The input and output delineate the domain of study: for example, for an activity like "make coffee", the knowledge capital is not the same if the output is "coffee" or "coffee served and dishes washed!"

– The second step is the identification of actors (knowledge actors) who participate, in the accomplishment of the mission, in the enrichment or use of the knowledge capital.

The term "actor" is used in a broad sense. It can of course include physical people (operators, specialists, supervisors, managers, etc.), but also materials (processes, software, etc.), and specific subsystems (statistical service, legal service, external organization, etc.) insofar as these agents are bearers of knowledge and operate in the system studied.

An actor is positioned if possible either in the decision system (decision-making actor), in the operating system (operational actor) or in the information system (this is a specific case, see below).

The actors are identified by the following elements:

– Title: A name.

– Role: the actor's set of tasks that contribute to the system's objective. For example, what are the objectives, expectations or tasks of the agent in the identified practice?

– Information consumed: Set of materialized information (or "that it is possible to materialize") – in the form of documents, electronic data, etc. – used by the actor to fulfill their role.

– Information produced: Set of materialized information (or "that it is possible to materialize") – in the form of documents, electronic data, etc. – produced by the actor in the accomplishment of their role.

– Knowledge used: Set of theoretical knowledge, know-how and social skills necessary for the actor to accomplish their role.

– Knowledge provided: Set of knowledge or know-how developed by the actor while accomplishing their role. For example, what are the new competences acquired by experience in the role, or the new knowledge created by the practice?

It is necessary to aim for exhaustivity in the list of actors to have a good idea of the knowledge capital of the system studied. The set of actors who contribute to the knowledge capital often far exceeds the work framework (process, laboratory, service, unit of production, etc.) that collects this capital. Often, exterior collaborators or subcontractors intervene in the operating system and authorities (legal, regulatory) intervene in the decision system.

An actor is only relevant in the model if they contribute effectively to the knowledge capital, which is to say if they bear knowledge that is useful to manage. For example, the "paper-and-pencil" in a service is generally not an actor to retain (they only provide the knowledge "knowing how to read" and "knowing how to write" that is rarely interesting to put in the knowledge capital). However, a technical device is generally a relevant actor in the operating system, because it often carries knowledge (knowledge of its design or its use, for example) that is not always well known or explicit.

The actors in the information system are in fact sources of information used or produced by and for the system. It is not always appropriate to define the information system actors with all the usual attributes (except, for example, to say that the knowledge that they contain is the knowledge provided in the knowledge capital, or knowledge that is useful to manipulate it is the knowledge used). We are often content with a list of the information sources. It must be verified that this list is in accordance with the compilation of attributes of "information consumed" and "information produced" of all the actors.

Generally, following the clarification of the objectives pursued in the identification of the knowledge capital, it is not necessary to exhaustively link all of the attributes to all of the actors. A simple or structured list can suffice for a good understanding of the system.

The third step involves the synthesis of validation and analysis.

– The information identified (information consumed, information produced) are linked to the information system (they must therefore be consistent with the other potential sources of information found there).

– The knowledge capital is the compilation of the attributes of knowledge provided and knowledge used. Because these can be numerous and detailed, it can be useful to group them into general classes and create a summary classification.

These information and knowledge capitals can then be put into perspective and discussed to identify the problems related to them and the possible solutions to implement.

2.7. Conclusion

The model presented in this chapter is an alternative model to the vision developed in the past few decades about the company and the role of the information system within that company. It focuses on knowledge flows that result from interactions between actors and the information system.

It reflects on the phenomenon of knowledge accumulation within a company, and the existence of a system that is knowledge capital. The latter is the fundamental concept around which the majority of KM expectations and challenges revolve.

It is therefore a model that companies ought to assimilate bit by bit in order to implement new strategies and new tactical and operational approaches that respond better to the new challenges related to KM.

3

The Structure of Knowledge

3.1. Introduction

Addressing the definition of knowledge is a real challenge. If there is one subject that has fascinated humankind for a long time, this is definitely it: what is knowledge, where does it come from, how does it spread, how it is transferred, how can it be represented? There are countless questions about it and the ways of addressing these problems are extremely varied. These approaches can be very diverse, stemming from philosophy, human sciences, biology, physics, etc. There is obviously no scientific definition of knowledge, and we cannot provide an irrefutable one here.

Knowledge, in an organization, notably a company, is not visible as such. It is only visible through certain traces (information, documents, discussions, groups of people, etc.). These traces are always related to an element in the company (a machine, a process, an experience, a unit of production, etc.). They represent this element as an active and relatively stable system of the company, a complex system in the sense that it is difficult to have an intelligible vision of it, inasmuch as the traces can be numerous, fragmented and lacking obvious coherence. This is how knowledge forms, through the perception of these systems that create traces, to better understand and better control them.

We propose two interdependent ways of perceiving systems in a company that result in two possible ways to structure knowledge.

The first way is the perception of a system through the messages that it sends us and the codes that it expresses. On a given system, when we read a

Knowledge Management: The Creative Loop, First Edition. Jean-Louis Ermine.

document, discuss with colleagues, observe, consult a database, take a course, etc., we receive multifaceted messages with which we create knowledge. These messages are designated under the general term of signs, and therefore the system is perceived as a sign system. This involves a certain way of structuring knowledge in this system called the "semiotic triangle".

The second way is the perception of a system as a general system (please excuse the apparent tautology!), in the sense of General System Theory, popularized in France by Jean-Louis Le Moigne's famous works [LEM 77]. The definition of a general system has long been debated. We will adopt Le Moigne's "trivial but mnemonic" definition:

> "by accepting an ordinary definition of the word "object", [a system is defined as] an active and stable object that evolves in an environment, in relation to some purpose". [LEM 77]

If the system is perceived as a general system, this implies a certain way of structuring knowledge in this system called the "systemic triangle".

3.2. The semiotic triangle of knowledge

A system can be perceived by us as a global set of elements (abstract, concrete, conceptual, material, etc.) that, even if we have difficulty distinguishing or interpreting them, communicate to us something that provides a meaning, a signification, an inherent cohesion of the system. It is the global perception of these elements that causes us to say – or it would cause us to say it if we reflected on it more first – that there is indeed a system capable of observation, even modeling, that we do not yet know, that we perhaps cannot even name at this time. It is a *sign system*, that gives us indications about what the system that we are observing is and that allows us to construct the knowledge that we can obtain from this system.

Therefore, we can formulate a first hypothesis about knowledge (semiotic hypothesis): knowledge is the perception of an organized system of abstract elements (a sign system) through messages provided by the system.

This requires specifying the nature of a sign. This problem is not new (it goes back to Plato and Aristotle) and it is vast. It is not our intention to reopen this debate. We will only sketch a basic theory of the sign that has been studied and formulated under many aspects and terms across the ages and that is a reasonable foundation that is recognized by all (we will refer to the foundational works by Umberto Eco [ECO 76, ECO 88]). All perceptible phenomena are observed based on three inseparable levels: the referent or the sign (the manifestation), the signified (the designation) and the signifier (the meaning) are perceived based on three dimensions: syntactic, semantic and pragmatic. This combination of perspectives is inseparable. This is confirmed by Jean-Louis Le Moigne:

"We cannot [...] manipulate a symbol by acting as if it was only a sign a priori devoid of signification and adaptability" [LEM 90].

Therefore, the knowledge of all systems can be seen as the weighted combination of three inextricably linked points of view. These three points of view have been given many names [ECO 88], but here, we will use the following three terms (this choice being only a terminological convention): syntactic, semantic and pragmatic, which are represented by a triangle, the semiotic triangle, which is also sometimes called the Ogden–Richards triangle (Figure 3.1).

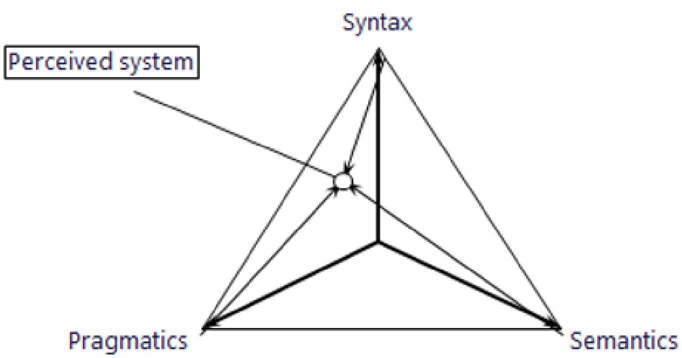

Figure 3.1. *The semiotic triangle*

It is now important to define what we mean by syntactic, semantic and pragmatic for knowledge. To do this, we will state three hypotheses.

The first hypothesis is that the syntactic aspect of knowledge concerns *information*. The term "information" is so often used, so worn out and tired, that it must be simplified (see Chapter 1). Let us say, to simplify, that information concerns the visible part, the shape of the knowledge, just as spelling or grammar pertain to the visible part of language. This is the perspective that is concerned with the form into which knowledge is translated and the code that it uses to *take form*.

The second hypothesis is that the semantic aspect of knowledge concerns the *signification* of information, which is evidently distinct from its form, just as in language, the meaning of a sentence does not (or not only) depend on its syntax (as shown by Chomsky's famous example, "colorless green ideas sleep furiously", which has completely correct syntax without having any meaning). It is not enough to accumulate data about knowledge, it is also necessary, in one way or another, to add meaning to these data to obtain something the slightest bit relevant. The accumulation of information (in the raw sense) does not make knowledge any more than an accumulation of bricks makes a wall! This point of view is concerned with the content instead of the form of knowledge, of the structure it uses to *make meaning*.

The third hypothesis is that the pragmatic aspect of knowledge concerns the *context* in which the meaning that we just talked about is used and that, as we can easily imagine, strongly influences this component. Knowledge does not exist simply because it has a form and a given meaning, but also because this form and meaning are provided in a setting that gives it its depth and relevance. This point of view is concerned with the system, the environment that knowledge uses to *be put in context*.

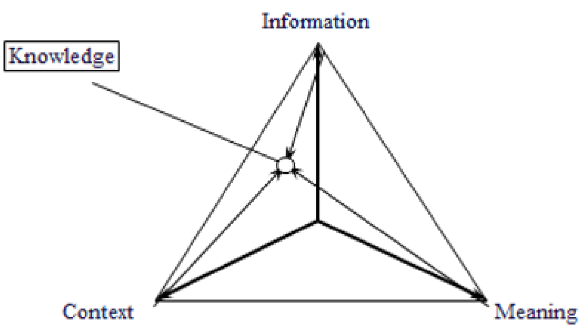

Figure 3.2. *The semiotic triangle of knowledge*

The semiotic hypothesis defines knowledge as *information* that is given *meaning* in a given *context* (Figure 3.2).

A simple example can be used to illustrate this definition. If we want to describe a watch, a clock or more generally any device that indicates time, we can describe it with these three points of view. The first concerns information. Figure 3.3 shows us how such a device communicates information about time through two different coding systems. It should be noted that, even if we can easily decode this transcription because of our education, it is not at all obvious. In the first system, the smaller hand is on the number 12 of a circle with 12 numbered subdivisions and the larger hand is on the number 11. In the second system, the number 11 is separated from the number 55 by two superimposed dots. This is the information communicated to us by the two systems. They are very different, but they indicate the same thing to the person receiving these messages.

Figure 3.3. *Two different systems of coding time*

If we take the point of view of the meaning of the message, it may seem obvious that the interpretation of the message is the time displayed. However, even this basic signification is ambiguous, because it can consist of “five minutes to noon” or “five minutes to midnight”. The ambiguity is dispelled by the context, depending on whether it is night or day. We can see that the context point of view intervenes quickly, and it is true that the meaning given to information almost always depends on the content in which this information is interpreted. If we are in a more complex context than simply reading the time, for example in a work situation, the signification of the message extends far beyond the time displayed. Consider the example of a class. The students see time differently than the teacher does. The students interpret it as the end of class approaching, which causes them to start packing up their things, for example. The teacher interprets it as an invitation to conclude, which causes the teacher to start thinking and speaking in a particular way. So, if we want to describe the knowledge in a given system, we must simply reduce it to the information that this system produces, but describe the context in which this system is situated, and what signification this information takes on in this context. We can well imagine the difficulty of doing this in a complex system.

In conclusion, the semiotic hypothesis tells us that knowledge is a representation of a system that is coded by information and this information has a meaning in a given context of interpretation.

3.3. The systemic triangle of knowledge

The definition of the general system as provided previously ("something active and stable, evolving in an environment, according to a purpose") results in a "triangulation", just as it does for semiotics. According to the theory (see [LEM 77, LEM 90]), a general system is observed based on three indissociable points of view. Here again, the words used to designate these three aspects are varied and depend on the connotation that we want to attach to them. The first point of view (called *ontological*) considers the system's *structure*, as it is perceived as a set of organized objects. The second point of view (called *phenomenological* or *functional*), considers the system's *function*, as it is perceived as acting, as "doing something". This is the point of view of the *action* of the system. The third point of view (called *genetic*), considers the system in its *evolution*, as it is perceived as modifying itself over time in accordance with its purpose.

Knowledge in every system can be seen as the weighted combination of three interdependent points of view, which, following convention, we will call: structure, function and evolution, represented by a triangle known as the systemic triangle (Figure 3.4).

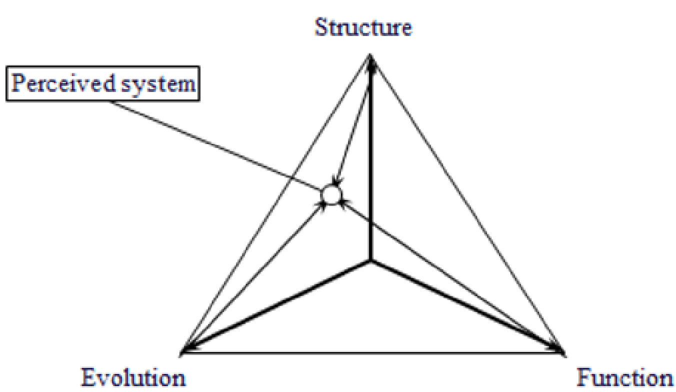

Figure 3.4. *The systemic triangle*

We will now formulate a second hypothesis about knowledge (systemic hypothesis): knowledge is the perception of a system according to structural, functional and evolutionary point of views.

In terms of representation, there are several ways to describe the structure, function or evolution of a system. Recall the example of a device that indicates time, such as a mechanical watch. The structural aspect is provided by the description of the watch mechanism: the arrangement of the cogs, parts, etc. The functional aspect is provided by the set of functions of the watch, organized in a diagram called the "functional diagram" or "block diagram". The evolutionary aspect is provided by a description of the history of mechanical watches over time.

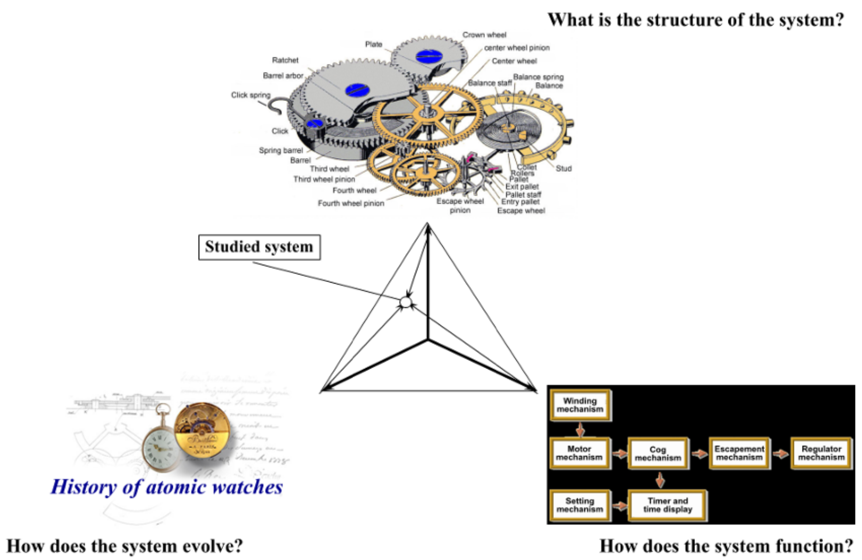

Figure 3.5. *The three systemic points of view for mechanical watches*

These points of view (Figure 3.5) provide a very rich representation of knowledge about mechanical watches. We could even say that this representation could almost be developed infinitely for each point of view. The position of the observer will determine the boundaries and the quality of the representation. Clearly, a watchmaker will focus essentially on the structural aspect, a user will focus primarily on the functional aspect, and a historian will be interested in the evolutionary aspect. Generally, an observer will construct knowledge on the subject using the three points of view, balancing them based on the context and their concerns.

In conclusion, the systemic hypothesis tells us that knowledge is a representation of a system that describes its structure, function and evolution.

3.4. The knowledge macroscope

In the previous sections, knowledge was defined according to two different filters: the semiotic triangle and the systemic triangle. These definitions result in two very different treatments. The semiotic approach is very focused on information processing, where information must be completed by the semantic and contextual aspects, which almost all information processing tools on the market strive to do. The systemic approach is very focused on system analysis, which can be achieved with many existing analysis and modeling tools.

It is productive to merge these two approaches to reach an enhanced definition of knowledge. This is possible because of the very nature of the informational, semantic and contextual points of view of knowledge, which have been studied for a long time by very diverse disciplines. Here, we propose a new completed definition of knowledge, combining the semiotic approach and the systemic approach. This approach results in a "triple triangulation" represented by what is called a *knowledge macroscope*, in reference to a concept developed by Joël de Rosnay [ROS 75].

In the study of complex systems, we readily use analogies with scientific analysis tools like the telescope or the microscope. For example, Claude Levi-Strauss analyzed the microscope as a tool of observation in this way:

> "An optical microscope [is] incapable of revealing the ultimate structure of matter to the observer, we can only choose between various degrees of enlargement: each one reveals a level of organization which has no more than a relative truth and while it lasts, excludes the perception of other levels" [LEV 69] (Volume I).

With such a tool, we only control a partial point of view of the system. We can choose its magnification level, we discover in it an organization, an entirely relative "truth", that ignores that of the other levels. Levi-Strauss's example is in fact a criticism of our cultural habits, since the analytical method that has reigned supreme for centuries in our cultures teaches us that we must reduce a problem to be able to solve it. Reducing to one aspect is no longer sufficient to address the complexity of the systems that we observe nowadays. It therefore consists of inventing a new tool that, like the microscope or the telescope, allows us to explore and discover systems in a productive and relevant way, in this new dimension of complexity, which allows us to have a global and non-reductive perspective of the systems. The change is significant, because it certainly does not consist of a physical or material tool, on the contrary. This is how Joël de Rosnay poses the principle of the macroscope:

> "The macroscope is unlike other tools. It is a symbolic instrument made of a number of methods and techniques borrowed from very different disciplines. [...] It is not used to make things larger or smaller but to observe what is at once too great, too slow, and too complex for our eyes" [ROS 79].

We will define a macroscope for structuring knowledge in a complex system that will allow us to analyze and control it. The macroscope is constructed by breaking down each point of view of the semiotic triangle into the three points of view of the systemic triangle (Figure 3.6).

3.4.1. *Knowledge and information*

– *Structural point of view*: The definition of information has caused many debates, as we saw in Chapter 1. There is now a consensus (General Definition of Information [GDI]) [FLO 10] that we will repeat here: information is made of data that are well-formed (remember that "information" comes from the Latin "in-formare", "to give form to") and well-formed data have meaning (i.e. the data must be compatible with the significations – the semantics – of the system, code or language in question). Because the problem of meaning is addressed in another point of view, we will simply say that information is a set of well-formed data (informational data). However, we can give basic meaning to this information (for example the information must be formulated in a language understood by a human), but information as such cannot contain all of its possible significations. This definition provides the structural aspect of information.

– *Functional point of view*: This concerns *information processing* (sometimes synonymous with computing) that concerns all of the processes involved in any changes to the information. It describes how we can manipulate information. It is a very developed field in information sciences, communication, cognitive psychology, cybernetics, etc.

– *Evolutionary point of view*: This is a fairly simple aspect attached to information and information processing. In general, the evolution of systems of informational data is configured by a temporal marker like the date, version, etc. This is essentially a dating issue.

3.4.2. *Knowledge and meaning*

– *Structural point of view*: This focuses on defining the nature of meaning. A huge undertaking that borrows from linguistics, cognitive psychology and anthropology, because meaning is deeply rooted in human beings and their culture. It is translated by semantic structures (semantic data, as opposed to informational data) that are constructed and are sustained in the mental structures of human beings. The most well-known semantic structures are *semantic networks* (or *concept networks*) first designed in linguistics to become a way to represent organized knowledge, whether it is personal, for a group or for an organization. It is a representation of a set of concepts that are semantically related to each other by specific, well-defined connections.

– *Functional point of view*: This addresses the processing of semantic data. Semantic structures do not exist in a vacuum; they are constructed because they must be used with a certain goal in a certain action. This action is characterized by a problem to solve, an objective, and is described by a strategy constructed by the human mind in order to solve the problems, which represents what we call know-how. That is why semantic data are used by *cognitive tasks* (we will use the simplified term *tasks* here), which are problem-solving methods, also constructed and sustained in the mental structures of human beings.

– *Evolutionary point of view*: The meaning that can be given to the evolution of data, concepts, solutions, technical objects, etc. developed over time in a company is represented by "genetic classifications" constructed *a posteriori* that are called *lineages* (technological trees, etc.). Giving meaning to a set of concepts consists of making a reasoned, understandable and synthetic reconstruction of the main objects or concepts that defined the evolution of the knowledge system studied. These concepts follow a timeline where the "why" and "how" of each evolution of the concept is identified. A set of lineages describes successions in time of concepts or objects in an evolutionary order "which we generally say moves in the direction of progress, through successive improvements or development" [DEF 85], thus describing "general trends" or "laws of evolutions". The lineages are organized in a *genealogical tree* that retraces the appearances and potentially the disappearances of lineages in relation to one another. The set of theories that focus on this representation, in the technical domain, is summarized in the book [DEF 85], which summarizes the theories that are the foundation for the history of techniques and technologies in human groups (A. Leroi-Gourhan, J. Baudrillard, A. Moles, G. Simondon).

3.4.3. *Knowledge and context*

The context addresses knowledge as it is integrated in a system, in the sense of a general system. It is therefore important to represent this system to give knowledge context.

– *Structural point of view*: This pertains to the domain of knowledge. To have a global view, the domain is represented as a general system "covered with *phenomena*". The hypothesis made here is that the main concepts that make it possible to describe this domain can be understood and take on meaning through general *phenomena* that are the basis of knowledge. These phenomena (as well as processes or effects) are the ones that we attempt to master, understand, trigger, optimize, prevent or moderate in the activity that we are focused on. Every activity always addresses these phenomena from a specific perspective. Experience shows that this model is indispensable and complementary for regular documents (scientific, reference, etc.).

– *Functional point of view*: This is a functional study of the knowledge system. It consists of identifying or defining the *activities* that it contains and their connections in terms of exchanges (of data, most often).

– *Evolutionary point of view*: To present this point of view, it is enough to cite Yves Deforge presenting one of the three fundamental tools for the study of the evolution of technical objects:

> "[this point of view] responds to the desire to better understand what happened at certain moments of an evolution by synthetically recreating around an object [around a concept], the

> network of mutual relationships that the object holds with all of the sub-systems of larger systems that we call […] the "industrial system". [This approach was inspired by methods that would be familiar] to those who study phenomena that extend over long periods: ethnologists, archeologists, economists; for some relevant periods in an evolution, they consist in recreating, pictorially and dynamically, the environment associated with the phenomena in question" [DEF 85].

This consists of integrating the evolution of knowledge, a concept or an object into a contextual system that illustrates this evolution and makes it possible to globally understand the guiding principles that led the knowledge to its currently perceived state. This occurs through the description of history where the historical context is described by a small number of elements that appear pertinent, over the course of the historical analysis, to describe and encompass the evolutionary context. The historical context extends far beyond the object of knowledge properly speaking, which finds itself placed in a signifying relationship, from an evolutionary point of view, with other subsystems.

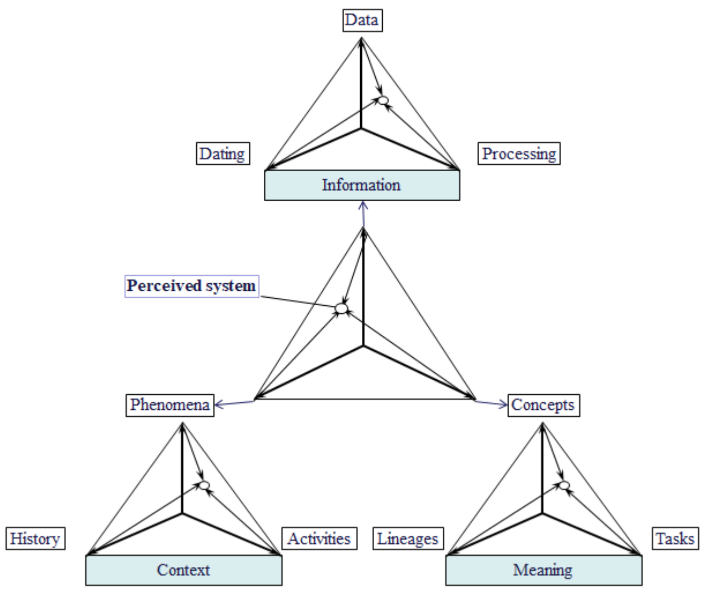

Figure 3.6. *The knowledge macroscope*

In conclusion, the structure of knowledge is given by three "semiotic" points of view, each point of view being itself given by three other "systemic" points of view, which in total makes nine points of view organized in the knowledge macroscope (Figure 3.6):

– information related to a knowledge domain is structured by informational data, information processing and information dating;

– the meaning related to a knowledge domain is structured by concepts, tasks that describe know-how and lineages that describe the evolutions of the domain;

– the context related to a knowledge domain is structured by phenomena, the organization of activities and history of the domain.

3.5. Practical application

The operational application of the principles noted above is common in practice, implicitly or not. The semiotic triangle is the foundation for design analyses that concern information and communication technologies: databases, information systems, software, etc. The systemic triangle is the basis for systems analysis in industry: production systems, supervision systems, etc. Several modeling techniques exist for each point of view (see, for example, Chapter 2, section 2.5).

Concerning the knowledge macroscope, the typical example is the capitalization method of the MASK method (called MASK 1 for historical reasons). This method provides specific knowledge models for each point of view of the macroscope (with the exception of informational points of view, which are processed by software engineering models). There are graphic languages that make it possible to describe and structure a knowledge corpus in any domain. The MASK 1 method is mostly used to explain the tacit knowledge of a person or a group of people. This is the "knowledge books" technique that will be explained later in this book. Without getting into the MASK 1 technique, it is possible to apply the macroscope on a knowledge domain, which is the example that we will develop now.

To give an idea of the knowledge macroscope, we have chosen an example that everyone can understand and complete at their leisure, which is a recipe. We have chosen pastry dough, inspired by the cookbook *La cuisine de Maguelonne*. This book is a culinary classic, and the author, Maguelonne

Toussaint-Samat, is an authority in the field, especially in the history of cooking (which will not, however, be addressed in this example, where the historical and lineage points of view will be absent). It consists of identifying the information point of view (data and processing), the meaning point of view (concepts and tasks) and the context point of view (phenomena and activities).

– *Information*

To describe a pastry dough recipe in terms of information, we can first populate a database with all of the information that is necessary and sufficient to create the dough. Here is an idea of what that could include.

– *Data*

- Data about the ingredients:

Flour:
Available quantity (kg)
Suppliers
Eggs:
Available quantity (whole)
Laying date (dd/mm/yy)
Suppliers
Milk:
Available quantity (l)
Type (skim, 2%, raw.)
Suppliers
Etc.

- Data about the instruments:

Oven:
Operating temperature (°C)
Preheating time (mn)
Width (cm)
Etc.

- Data about the process:

Tart shell:
Baking time (mn)
Quantity of flour (g)

Number of eggs (whole)
Etc.

Next, we can imagine an information processing aspect that can be multifaceted and varied. Here are a few examples.

– Processes:

- Stocks management:

If the quantity of flour is < n kg
Then
    Choose a supplier
    and place an order
As long as the order is not filled
    Contact the supplier again
Record the quantity of flour included
Etc.

- Oven operation procedure:

Turn the oven on
When the preheating time is finished
Let it be *during* the given baking time
at the operating temperature of the oven
Etc.

- Making the tart shell:

Mix the quantity of flour with the number of eggs
Add the quantity of milk
Etc.

We may note that, intuitively, some data contain know-how, like the width of the oven, which are data that comes from experience (!), and not knowledge that is specific to the recipe.

All of the data that are necessary and sufficient for making this recipe can be transcribed this way. This is not to say that we have accumulated the associated knowledge or know-how. The other points of view of the knowledge macroscope will be addressed now, which will usefully complete this "Database" approach.

– The meaning

The meaning is described as a cognitive representation of the expert (in this case the baker) who gives “substance” (or “gives meaning”) to the information that was identified.

- In structural terms, the meaning is described as a classificatory structure that organizes and defines concepts that the expert manipulates. In this example, it consists of the classificatory knowledge of the field of pastry dough making, which is easily recognizable in the cookbook studied. Here is the classification provided by an expert in pastry dough:

- Pastry dough
    - Pie dough
        - Shortcrust dough
            - Savory shortcrust dough (rissoles, savory tarts, croustades, meat pies)
            - Sweetcrust dough (pastry tarts)
        - Shortbread dough
        - Puff pastry dough
    - Yeasted dough
        - Classic bread dough
        - Brioche dough
    - Cake dough
        - Biscuit dough
        - Choux dough

- In functional terms, the meaning is described as the representation of a task that is constructed by the expert when they accumulate know-how and experience in the exercise of their activity. This representation is personal. In a recipe, it is translated by a very consistent set of skills, tricks that are described in the cookbook. It is impossible to translate such a set of tasks into an algorithm or procedure due to the large number of imprecision, non-prescriptive advice and the limit of so-called “tacit knowledge” (the concept of “lightly salted water” is stated but not defined and must be tacitly reconstructed by the learner through experience). Here is a description of the tasks involved in making bread dough:

> "To make bread dough, place the flour in a large bowl and set aside 200 g of flour. Make a well in the flour, add lightly salted water and dissolve the baker's yeast. Work the dough by hand, while regularly dipping your hands into the flour you set aside. To make the loaf, cover the dough with a floured cloth for thirty minutes. If you want to make a special bread, add the ingredients (nuts, olives, etc.). Then, bake the dough…" [TOU 88].

– *The context*

The context describes the major basic principles, the main features in which the knowledge domain under consideration is found.

- The structural aspect is the description of the theoretical foundations of the knowledge domain, but seen from a "professional" perspective. In the recipe example, they describe the fundamental phenomena that must be understood to successfully create a pastry. For example, we can read in the cookbook:

> "For the shortcrust pastry, the kneading technique makes it so that the flour particles coated in fat remain sufficiently impermeable to the steam released by the baking. This steam, trying to escape, pushes on the pastry so that it expands a bit, just enough to remain light and crispy" [TOU 88].

- In functional terms, it simply consists of analyzing the activity, which describes the main activities that break down the process of the basic action (of the "profession") concerned by the domain. In the recipe example, for example, it is the activity of making the dough. We can note hyperlinked references to other types of knowledge described in other information sources. Here is an extract of the process of making pastry dough:

- Phase 1: Prepare the dough. To complete this phase, it is necessary to use the data about the ingredients (see Chapter "Information");

- Phase 2: Let the dough rest;

- Phase 3: Shape the dough. To complete this phase, for example, we can refer to the know-how described in the previous section about "How to make bread dough";

- Phase 4: Bake the dough. To complete this phase, it is useful to refer to the baking phenomena, like the one described previously.

In conclusion, the application of the knowledge macroscope on a knowledge domain makes it possible to structure the knowledge corpus of a domain in a relevant and fairly exhaustive way.

3.6. Conclusion

The problem of structuring knowledge in a company or any other social organization falls under the issue of complex systems, which is only approachable through knowledge that we can construct about these systems. Understanding such systems can occur through two types of filters. The first filter is that of messages that we perceive from a system that are translated by information produced by and about this system and especially the meaning that these messages take on in relation to contexts of observation or analysis. The second filter is that of systemic analysis, which analyzes a system based on its structure, its function or its evolution. These two filters are constantly used, implicitly or not, to produce and use knowledge in a system. The knowledge macroscope developed in this chapter is a way to merge these two approaches by integrating classic elements elaborated by various theories in several domains, from the hard sciences and human sciences. The macroscope is a structured definition of knowledge that allows for a detailed analysis of a knowledge corpus.

4

Shannon's Theory of Knowledge

4.1. Introduction

A formal theory of information became a pressing issue around the 1940s, when we began to manipulate information technically, in a substantial way, through its transmission in telecommunication systems. We owe this theory to Claude Shannon, a researcher at Bell laboratories in the United States. Originally intended for engineers to solve very specific and technical problems, this very mathematical theory quickly surpassed its initial objective and invaded the field of reflection about the nature of information and communication. In his remarkable foreword to the French edition of Shannon's book, Abraham A. Moles analyzes this phenomenon of the *crystallization of thought* that caused Shannon's work to reach a *threshold of intellectual celebrity*, as a necessary component in all reflection about communication processes ("[this book] was universally cited at the head of bibliographies by everyone who directly or indirectly touched on the theory of information, simultaneously out of caution (and sometimes security), thoroughness, and intellectual reference" [MOL 75]). We will refer to the excellent book compiled by D. Bougnoux on this issue [BOU 93].

In our societies, we continue to spend a lot of effort gathering and disseminating information that is sometimes very complex but often, in the end, still reducible to a quantity of information in the sense given by Shannon, and not sufficiently associated with any "knowledge". As Umberto Eco said, "The principles of the theory of information – with the exception of some specialized discourse – are most often cited in a fetishistic way or as *flatus voci*. As a result, terms like 'information' and 'entropy' or others are

Knowledge Management: The Creative Loop, First Edition. Jean-Louis Ermine.

used metaphorically. We must patiently return them to their original signification" [ECO 72, Sec. A, Chap. I, section I.4]. An extension of Shannon's theory to knowledge would have the merit of positioning information in its proper place, while also providing productive metaphors, provided that they are used with discretion. In addition, a formal theory has the advantage of being refutable, unlike informal discussion. It can generate criticism, challenges, alternatives and improvements.

Philosophical, psychosocial, managerial, operational, technical, etc. debates about knowledge are not currently able to provide a formal theory of knowledge. It is even likely that all of these approaches would reject such an attempt. However, the developments in knowledge management and knowledge engineering contribute to providing formalized frameworks for such a theory. A certain maturity has been reached in this domain, and it is possible to use these advances to lay the foundations for such a theory.

The proposition made here [ERM 07] is based on the formal frameworks described in the previous chapters.

4.2. Some definitions and notations

4.2.1. *The basic unit of knowledge*

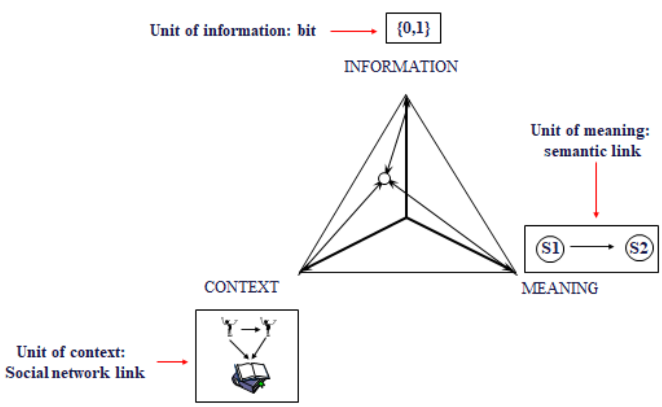

Figure 4.1. *The kit (knowledge unit), elementary unit of knowledge ("cogniton")*

According to the semiotic theory in Chapter 3, knowledge is composed of three points of view that we identify as information, meaning and context.

The theory of information provides a formal means to code messages (informational corpora) with elementary units formed of 0 and 1 and from there makes it possible to formally define a quantity of information in an informational corpus (a message) (see section 4.2). The elementary unit of information is the bit. A bit measures one piece of elementary information.

Following this theory, we can question whether it is possible to define an elementary unit of knowledge (a "cogniton", to borrow from the molecular theory of matter!) that would make it possible to define an elementary measure of knowledge (the "kit": knowledge unit). From there, we could measure the quantity of knowledge contained in a knowledge corpus.

According to semiotic theory, an elementary unit of knowledge is formed by an elementary unit of information (which is known, it is {0,1}), an elementary unit of meaning and an elementary unit of context.

In linguistics, the elementary unit of meaning is called a "seme". It is often represented by a significant term, framed by / signs so we distinguish it from its ordinary usage in language (for example /beautiful/, /feminine/, /white/, etc.). The semantics of a knowledge corpus are represented by the semes that it contains as well as by the semantic relations that connect the semes. This is called a semantic network. There are many works about semantic networks, as much in cognitive sciences as linguistics and artificial intelligence. We can formally define an elementary unit of meaning as a set of two semes connected by an arc. Meaning is constructed by combinations of elementary units of meaning. The elementary unit of context is problematic, because to our knowledge, there has been no attempt to formally define the context of a knowledge corpus. Therefore, we will make pragmatic choices that are very reductive, but that will allow us to move forward.

By context, we mean context of use, which is to say the use of a corpus by a community concerned by the knowledge included in the corpus (knowledge community). It is not only the use that the people concerned make of the corpus, but also the relations that are established between these people that are significant for the context of the corpus (this is the very notion of social community). We can therefore formally define an elementary unit of context as a given knowledge corpus, related to two knowledge actors, who are themselves related to one another by a social relation.

4.2.2. *Measuring knowledge*

If I denotes the space of information, S_e denotes the space of meaning and C_o denotes the space of context, we define the space of knowledge K as:

$$K = I \times S_e \times C_o$$

$$\forall k \in K, \exists i \in I, s \in S_e, c \in C_o: k = (i,s,c)$$

Thus, if $k \in K$, we can define three evaluation functions with real values:

$$Val_I: \quad I \longrightarrow \mathbf{R}$$

$$Val_S: \quad S_e \longrightarrow \mathbf{R}$$

$$Val_C: \quad C_o \longrightarrow \mathbf{R}$$

evaluating the information value, the semantic value and the contextual value of knowledge, respectively.

The global value of knowledge is represented by a vector in a three-dimensional space:

$$Val(k) = (Val_I (k), Val_S (k), Val_C (k))$$

We can generalize the notion of value to a set of knowledge, which we will call a "knowledge corpus".

DEFINITION.– A knowledge corpus H is an element of P(K), the power set of K.

By extension, we define:

$$Val (H) = \int_{h \in H} Val(h) dm$$

for a measurement m, such that the integral exists.

By definition, we say that Val(H) measures the value of the corpus H.

Intuitively, this is equivalent to assuming that information, meaning and context can vary independently. We can imagine a knowledge corpus that has a lot of information and little meaning (such as a phone book), a lot of meaning and little information (such as a proverb or a conceptual model of data for an empty database), a lot of meaning but little context – in the sense of usage context, see section 4.5 – (such as a personal diary, blogs, a rarely viewed website), little meaning and lots of context (such as a persistent and widespread rumor), etc.

4.2.3. *Quantity of knowledge in a corpus*

We will now study a value function that is a set of three real numbers measuring the "quantity of knowledge" in a corpus. The definition of a measurement of the quantity of knowledge in a corpus is not only a theoretical objective.

Being able to define the quantity of knowledge in a corpus can lead to several innovations, such as:

– scoring information retrievals. Starting from a keyword search, search engines rank the corpora they find based on their relevance. This relevance can be calculated based on the content (such as the occurrence of terms) or on the contextual value of the site (such as the number of connections). A more detailed quantification of the context in semantic terms and more detailed indicators about its usage context allow for a much more relevant ranking;

– improving document content. The theory of information makes it possible to find the optimal coding for a piece of information. By analogy, if we have a measurement of the quantity of knowledge in a corpus (a document, for example), this can very naturally lead to rebuilding the original document so that it is better perceived in relation to the reference meaning;

– supervising a knowledge community. The context of a knowledge corpus is essentially evaluated by its usage context. Giving refined indicators of the usage communities of a knowledge corpus makes it possible to recognize these communities and facilitate their improvement.

The measurement of the quantity of knowledge in a corpus is therefore a set of three real numbers that measure, respectively, its "quantity of information" (informational measurement), its "quantity of meaning" (semantic measurement) and its "quantity of context" (contextual measurement). We will give an example called Shannon's measurement of knowledge.

4.3. Measurement of the quantity of information in a corpus

The quantity of information function is relatively simple and well known: the measurement of the quantity of information in a corpus is given by the theory of information. We will briefly introduce it here. An elementary unit of information is defined by the bit, which has the value 0 or 1. Let us look at the example discussed in detail in [ERM 00] to illustrate this concept.

For example, we can try to represent the information transmitted by a traffic light in an abstract way. The most common way to represent the signals transmitted is to assign the digit 0 to a light that is switched off, and the digit 1 to a light that is switched on. The set of three lights, which constitutes the traffic light itself, is then represented by a number with three digits, each one able to take the value 0 or 1. Arbitrarily, we assume that the first digit represents the red light, the second represents the yellow light and the third represents the green light. The abstract representation obtained is summarized in Figure 4.2.

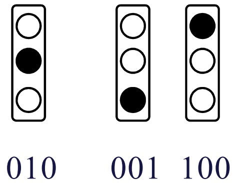

Figure 4.2. *Abstract representation of information from a traffic light*

If we consider the elementary knowledge in its informational part that is provided by the traffic light, we observe that it is fairly small because it can be represented by three numbers with three digits. The numbers, which are the abstract representation of this information, form a *code*, constituted of binary information (0 or 1) called *bits* (condensed from the expression *binary digits* or *binary units*). Therefore, we can say that the traffic light's messages contain three bits of information (in fact, we can reduce it to two).

In computer science, all digital corpora can be measured in terms of bits (or bytes – 8 bits – or multiples of bytes). We can therefore define the quantity of information contained in a corpus with this measurement. Because the latter is related to a computer storage system, we must provide a reference storage system. This measurement is extremely common.

We can generalize this notion for a non-digital or specific corpus and define a quantity of information, still in relation to a reference storage system. For a reference storage system, it consists of tallying the number of units occupied by the corpus: the number of sections or number of works in a documentation service, number of pages or number of characters in a written document, number of bits or bytes for digitalized information, etc.

The theory of information can estimate the quantity of information contained in a corpus. As previously, in the traffic light messages example, we saw a means of coding (representing) corpora using elementary units of information. Since we have the formal means of coding the corpus, can we formally define what a quantity of information is from there?

There are several approaches that attempt to do so. If we take the usage perspective, which is to say the perspective of the person who is the receiver or the intended recipient of the message, we can try to determine how to recognize a message that is transmitted by a traffic light.

We can describe a linear and algorithmic process that has nothing to do with the reality but carries out the desired function. First, we must try to find out if the first light (the red light) is switched on. For this, we must make a binary choice, because there are two possibilities; let us assume that the red lamp is switched off (path 1 in Figure 4.3). Then, we must find out if the second light (the yellow light) is switched on. Again, there is a binary choice to make. Let us assume that it is switched on (path 1.1 in Figure 4.3). Then, there is one final binary choice to completely decode the message (path 1.1.1 or 1.1.2). In all cases, one of these messages is not significant. This is general, as we can see in Figure 4.3: to manage to decode the message received (at least with the procedure defined above), there are always three binary choices to make. This is due to the fact that we coded the set of messages on three bits. We can say that the *quantity of information* contained in the message is three. This quantity measures the freedom of choice that is available when decoding a message. "To be sure, this word information in communication theory relates not so much to what you *do* say, as to what you *could* say" (Weaver) [SHA 98].

Another way of viewing this quantity of information is through a probabilistic perspective, which is the basis for Claude Shannon's theory [SHA 49]. During a communication, the receiver is awaiting the message: when he knows that he will look at a traffic light, he already has an idea of the messages he can expect. *A priori*, he is not aware of which message will be addressed to him. However, because of his experience (learning the traffic laws minimum, in this case), he expects to receive certain messages with different probabilities. In the case described above, we posited that all messages that can be potentially transmitted by the traffic light are equally likely, which is obviously false in reality. Let us reuse this calculation, although it may complicate things. Because there are eight possible messages, the probability of the appearance of a message is P = 1/8, but once again, the coding makes it possible to count messages in a binary way, which corresponds to $8 = 2^3$. To find the quantity of information from the probability of a message, a small mathematical formula using the logarithmic function will suffice: $3 = -\log_2 (1/2^3)$, which is where we get the general formula for the quantity of information Q in a message m whose probability of occurrence is P: $Q(m) = -\log_2 (P)$.

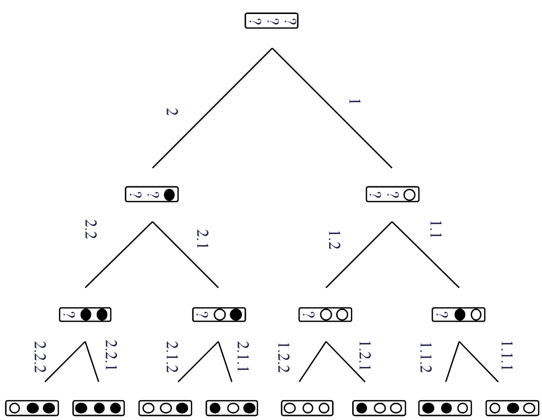

Figure 4.3. *Set of possible messages from a traffic light*

In reality, traffic lights obviously work differently. We can posit (in France, at least, because it is not the same in all countries) that only four cases actually occur: only the Red light is switched on (45% of the time), only the Yellow light is switched on (9.5% of the time), only the Green light is switched on (45% of the time) or no lights are switched on (0.5% of the time, when there is a power failure). This example reflects the reality of information systems for which equiprobability is only a very improbable configuration. The quantity of information Q of a message m in which the probability of occurrence P is calculated by:

$$Q(m) = -P \times \log_2(P)$$

And for the complete system, the quantities of information of each possible message must be added. In our example, this gives:

$$Q(H) = -2\times0.45\times\log_2(0.45) - 0.095\times\log_2(0.095) - 0.005\times\log_2(0.005)$$

or

$$Q(H) = 1.4$$

The notion of the quantity of information is therefore gainfully replaced by the notion of *entropy*, which is a mean quantity of information in the sense of probabilities, a mean taken on the set of messages. If p_i designates the probability of the occurrence of a message mi, the entropy is by definition the mathematical expectation: $H = -p_1\log(p_1)\text{-}p_2\log(p_2)\ -...$ (H for Hartley, who was a precursor of Shannon). In the example in Figure 4.3, where all of the probabilities are equal to 1/8, we find that the entropy is equal to log(number of messages) = 3: the mean information of the set of messages is equal to the information of any given message in the set. In this case (all of the messages are equiprobable), the entropy is maximum.

This last remark leads us to an important comment. Entropy is a well-known notion in thermodynamics, and the fact that Shannon introduced a similar notion to quantify information is not just a simple analogy. This correspondence has been discussed at length, and it would take too long to pick up on that discussion here. We will simply say that entropy, in thermodynamics, measures the degree of molecular disorder in a system and that the greatest entropy corresponds to total molecular disorder within a system, which manifests at the global level by balance. Regarding information, the greatest entropy also corresponds to a sort of total "informational disorder": all messages are equiprobable, and when, to decode a message, we must make a binary choice (use a bit), there is no more reason to choose one choice than any other. There seems to be a paradox in this, which is more in the vocabulary than in the concept: a system that has maximum information (in the sense of entropy) only provides a minimum. If the messages are no longer equiprobable, therefore if the entropy decreases, the system is more "informative": ("We intuitively recognize that breaking news announcing the assassination of a head of state is very important, or contains a lot of information due to its very improbability, and that, on the other hand, a weather report on June 30 that announces the absence of snowfall the next day in Paris provides essentially no information at all" ([BOU 93], Chapter 5). This is why we often talk about information in terms of *neguentropy*, which is the opposite of entropy. Entropy therefore has the same meaning as information did previously, or the freedom to choose a certain source, or even the mean of the probabilities of occurrence of a set of messages.

The entropy function is very commonly used in physics and mathematics. In the theory of information, its introduction was a considerable innovation that proved to be extremely useful. In fact, Shannon introduced this function for simple reasons of consistency, starting from the moment when we have a distribution of probabilities on a set of events. These properties are stated in Shannon's historic article [SHA 48].

If we have a set of events whose probabilities of occurrence are p_1, p_2, … p_n, these probabilities are known, but they are the only thing that is known about the event that will occur. Can we find a measurement of the "noise" caused by the event selection or the uncertainty of its occurrence?

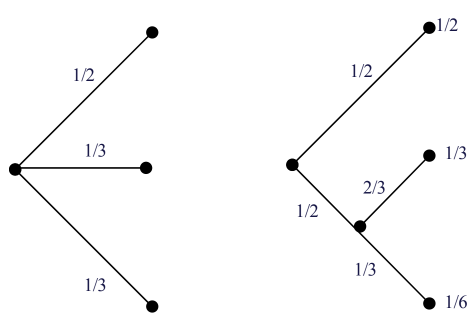

Figure 4.4. *Breakdown of the choices*

If such a measurement $H(p_1, p_2, \ldots, p_n)$ exists, it is reasonable that it would have the following required conditions:

– H is continuous in p_i;

– if all of the p_i are equal, $p_i = 1/n$, then H is an increasing monotone function of n (with equiprobable events, there is more choice or uncertainty when there are more possible events);

– if a choice is divided into two successive choices, the original H is the weighted sum of the individual values of H. This is illustrated in Figure 4.4.

In the case illustrated below, we have:

$$H(1/2, 1/3, 1/6) = H(1/2, 1/2) + 1/2\ H(2/3, 1/3)$$

So the only function that verifies these properties is:

$$H(p_1, p_2, \ldots, p_n) = -K \sum_i p_i \log(p_i)$$

Therefore, a value function for an informational corpus has a very specific form. This form is found in the other value functions for the other elements of knowledge: meaning and context.

For the function Val_I, the informational entropy of Shannon's theory provides us with the first function we need to define the entropy of knowledge.

4.4. Measurement of the quantity of meaning in a corpus

4.4.1. *Definitions and notations*

The semes of K form a finite set of elements ("signifying elements or terms") S.

We note so-called indexing functions as Ind:

$$\text{Ind}: P(K) \longrightarrow P(S)$$

that, for all knowledge corpora H, which is an element of P(K), connects a set of semes, which is an element of P(S).

A semantic graph is a set (V, E) where V is a subset of elements of S, which are called the vertices (or nodes) of the graph, and E is a subset of elements of $V \times V$, which are called edges (or arcs or links).

A graph (we will only discuss finite graphs here, whose vertices are numbered 1 to n) is characterized by its incidence matrix $P = [p_{i,j}]$: this is a square matrix (n,n), such that $p_{i,j} = 0$ if there is no link from vertex i to vertex j, and $p_{i,j} = 1$ if not.

A path of length n in a graph is a sequence $(s_0, \ldots, s_n)$, such that (s_i,s_{i+1}) is an edge of the graph for every i; s_0 is the origin of the path and s_n is the end point.

A graph is said to be connected if any two vertices can be joined by a path.

We note as $p_{i,j}(n)$ the number of paths of length n that start with the vertex i and end with the vertex j. It is also the coefficient of the line i and the column j of the matrix P^n: $p_{i,j}(n) = (P^n)_{i,j}$

A function of semantic graph construction is a function:

$$\Gamma : P(K) \longrightarrow S \times S^2$$

that for all knowledge corpora H, associates a semantic graph Γ(H), such that $Pr_1(\Gamma(H)) = Ind(H)$ (it is a semantic graph whose vertices form a set of semes that index H, Ind(H)).

4.4.2. *Quantitative characterization of semantic graphs: Gurevich entropy*

4.4.2.1. *Definition*

The semantic graph of a knowledge corpus characterizes the "semantic paths" that are possible in the corpus. Therefore, the topology of the graph reflects the semantic complexity of the corpus.

Similar to the theory of information, there is an extremely developed theory that accounts for the paths in graphs (meaning the semantic paths in semantic graphs), which is the theory of graph entropy [SIM 95]. We will provide an approach that was developed by Gurevich ([GUR 69], see [RUE 01]).

Consider G a graph and P its incidence matrix. We note as $p_{i,j}(n)$ the number of paths of length n originating from vertex i and the end point, the vertex j. It is also the coefficient of the line i and the column j in the matrix P^n. The Gurevich entropy of G is defined by:

$$h(G) = \limsup_{n \to +\infty} 1/n \log(p_{i,j}(n)) = \limsup_{n \to +\infty} 1/n \log((P^n)_{i,j})$$

For a finite connected graph, this value does not depend on i and j (this is not true if we consider, for example, paths that do not pass by the end point again). It represents the rate of exponential growth of the number of paths with fixed end point.

4.4.2.2. *Example*

To understand this notion of entropy, we will give a very simple example. Consider a basic phone book. Its semantics are represented by the semantic graph shown in Figure 4.5.

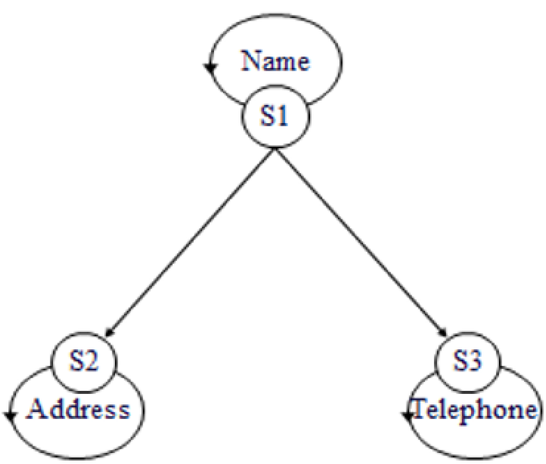

Figure 4.5. *Semantic graph of a phone book*

The incidence matrix of this graph is:

$$P = \begin{pmatrix} 1 & 1 & 1 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

If $A = \begin{pmatrix} 0 & 1 & 1 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}$, we have $P = I + A$ with $A^2 = 0$

Therefore, we have: $P^n = (I+A)^n = I + nA$, so $p_{i,j}(n) = 0$, 1 or n; therefore, h(G) = 0, the entropy of this graph is zero. It is obvious that, intuitively, its semantics are minimal.

We can complicate this simply by creating an inverted phone book where we can find the name based on the telephone number, represented by the graph shown in Figure 4.6.

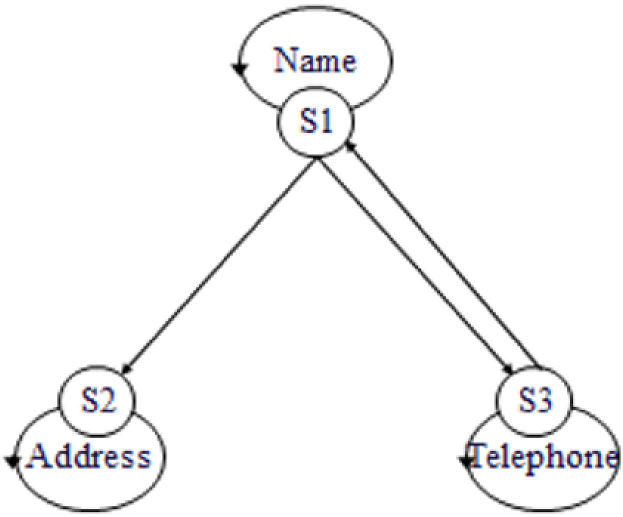

Figure 4.6. *Semantic graph of an inverted phone book*

The incidence matrix of this graph is:

$$P = \begin{pmatrix} 1 & 1 & 1 \\ 0 & 1 & 0 \\ 1 & 0 & 1 \end{pmatrix}$$

If $A = \begin{pmatrix} 0 & 1 & 1 \\ 0 & 0 & 0 \\ 1 & 0 & 0 \end{pmatrix}$, we have $A^2 = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 1 & 1 \end{pmatrix}$ with $A^2 = A^{2n}$ and $A = A^{2n+1}$ for all n.

Because P = I + A, this gives:

$P^n = (I+A)^n = b(n)\ A + c(n)\ A^2$, where $b(n) = \sum_{k.odd} \binom{n}{k}$ and $c(n) = \sum_{k.even} \binom{n}{k}$

because $b(n) = c(n) = 2^{n-1}$ (property of binomial coefficients), this produces the result:

$$P^n = = 2^{n-1}\ (A + A^2)$$

therefore $p_{i,j}(n) = 2^{n-1}$ or 0, therefore $h(G) = \lim_{n \to +\infty} (n-1/n) \log(2) = \log(2) = 1$ (the semantics of the new phone book increased by one bit of semantics).

4.4.2.3. *Quantitative characterizations of semantic graphs: Markov entropy*

We can generalize the notion of entropy previously in the sense of Shannon's theory by introducing a law of probability of transitions between the vertices of the graph G or the Markov measurement of G. If we consider the incidence matrix of G as a Markov chain transition matrix (modulo of coefficients to be added so that the sums of the coefficients of the lines are equal to 1), this means that the transitions between vertices connected by the graph are all equiprobable.

We can therefore generalize the semantic graph as a graph whose links are weighted by the coefficients (the sum of the coefficients of the links of a vertex is 1). This exists in some text analysis software that generate weighted graphs. Therefore, the incidence matrix P represents a stochastic transition matrix.

A stochastic process represents the evolution of a system on which a successive number of experiments (or no experiments), whose results depend on chance, are carried out. The system is characterized by a (finite) number of states that are possible and, we assume, known for each pair of states i and j, and for each experiment number n, the probability $p_{i,j}(n)$ that the process moves from state i to state j at a pace of n + 1. We also assume that the probability $p_{i,j}(n)$ is independent from n (from the experiment step). This process is called a Markov chain (in discrete time and with a set of finite states). With these hypotheses, we can describe the system by giving the set $\{S_i\}$ of possible states and a square matrix P whose term $p_{i,j}$ is the probability that the process will go from state i to state j. P is called the system transition matrix. We generally represent P by a *directed graph* G (Markov graph) whose *vertices* correspond to the states and whose *arcs* correspond to the ordered pairs of states (i,j) such as $p_{i,j} > 0$.

The probability, which we will note as $p_{i,j}(n)$, that the system will be in state j at step n knowing that it was in state i at step 0 is given by $(P^n)_{i,j}$ (the term i,j of the power n of P). So, if X_0 designates an initial state of the system (it's a row matrix of the probabilities x_i of being initially in state i), the state of the system X_n after n steps is given by:

$$X_n = X_0 P^n$$

If the sequence (X_n) converges toward X, X is called the limit or stationary state.

A stationary state $X = [x_i]$ verifies the equation of the fixed point (it does not depend on the initial state):

$$X = X P \quad \text{or} \quad [x_i] = [x_i] P \qquad (\text{with } \sum_i x_i = 1)$$

The existence of a stationary state is a basic problem in Markov chain theory. This existence depends on certain characteristics of the matrix P.

There is a relation between the convergence of the matrix P^n and a stationary state, which is given by an important theorem in Markov chain theory. This theorem says that if P has at least one power for which all coefficients are strictly positive (we say that P is regular), then there is a stationary state with strictly positive values, and the matrix P^n converges toward a matrix P* for which all of the lines are equal to the stationary state. We will see an example in the following.

In the theory of information, the entropy of the Markov graph G is defined by:

$$h_M(G) = \sum_i -x_i \log(x_i)$$

There is a theorem that gives the equivalence between this definition and that discussed previously ([GUR 69], see [RUE 01]), namely that for a graph G, there is a distribution of probabilities on the graph that makes a Markov graph like:

$$h_M(G) = h(G)$$

Because this equivalence is not *a priori* obvious, here is an example to explain it.

Consider the classic problem of the transmission of stories. A story is transmitted between individuals from mouth to ear. Each person retransmits the story either in its original version or in a modified version. We will assume that there are two modified versions and that each individual to whom a version is recounted has a probability p of recounting it as such and a probability q = (1 – p)/2 of recounting one of the other variations[1]. The matrix P is therefore written as:

$$P = \begin{pmatrix} p & q & q \\ q & p & q \\ q & q & p \end{pmatrix}$$

1 A surprising result of this phenomenon is that these values, p and q, have no influence on the limit value (in limit phenomena, all versions of the stories are equally likely).

which corresponds to the graph in Figure 4.7.

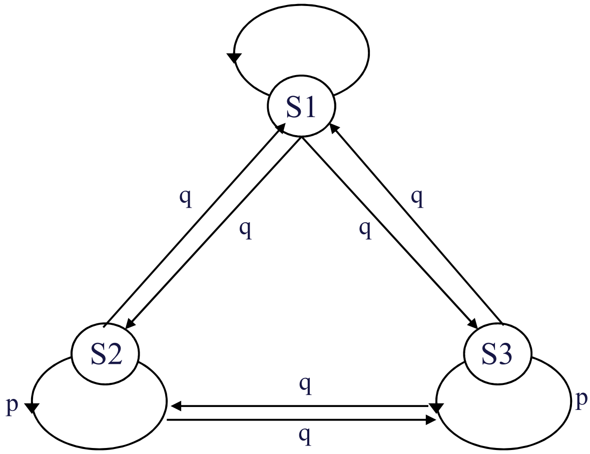

Figure 4.7. *Markov graph*

The diagonalization of this matrix gives:

$$P = 1/3\ T\ D\ T^{-1} = 1/3 \begin{pmatrix} 1 & 1 & 0 \\ 0 & -1 & 1 \\ 1 & 0 & -1 \end{pmatrix} \begin{pmatrix} 1 & 0 & 0 \\ 0 & p-q & 0 \\ 0 & 0 & p-q \end{pmatrix} \begin{pmatrix} 1 & 1 & 1 \\ 2 & -1 & -1 \\ -1 & -1 & 2 \end{pmatrix}$$

therefore we have:

$$\lim_{n \to +\infty} D^n = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix} \quad \text{and} \quad \lim_{n \to +\infty} P^n = 1/3 \begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{pmatrix}$$

Now let us calculate a stationary state.

The equation (x,y,z) = (x,y,z) P gives the system:

$$\begin{cases} x = px + qy + qz \\ y = qx + py + qz \\ z = qx + qy + pz \end{cases}$$

where x = 1/3, y = 1/3, z = 1/3 (this means that in a limit, it is not possible to know which one is the original version of the story because all versions are equally likely).

Therefore, for the Markov entropy, we have:

$$h_M(G) = -1/3\log(1/3) - 1/3\log(1/3) - 1/3\log(1/3) = \log(3)$$

If we consider the adjacency matrix of the Markov graph, it is:

$$A = \begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{pmatrix}$$

Calculating the powers of this matrix shows that $a_{i,j}(n) = 3\ a_{i,j}(n-1)$, so $a_{i,j}(n) = 3^n$.

Therefore, for the Gurevich entropy, we have:

$$h(G) = \log(3)$$

For the function Val_S, the Gurevich entropy provides the second function required to define the entropy of knowledge.

4.5. Measurement of usage context in a corpus

4.5.1. *Introduction*

The third component of our knowledge unit pertains to measuring its usage. We consider this measurement as the usage made by people concerned with a knowledge corpus, as well as in the relationships that are established between these people. This idea starts from the observation that a piece of knowledge that is deemed pertinent will be shared between its holder and those close to the holder, or that inversely, a piece of knowledge that is poorly distributed corresponds to something obsolete, uninteresting or inappropriate. We are aware that this approach overlooks some knowledge with great potential that remain guarded secrets. On the other hand, our model will apply perfectly to knowledge that we want to disseminate, via paper or electronic publication media, verbal communication, etc. and that only reflect the amount of interest that they elicit.

The usage context of knowledge or its dissemination potential will be addressed here through the acquaintance network that exists between holders and users of knowledge elements, whether they are individuals, groups or systems. This kind of network corresponds to the social networks studied in psychosociology and more recently in graph theory.

4.5.2. *Social networks*

The so-called "small-world" networks were introduced by the American psychosociologist Stanley Milgram who, in the 1960s, experimented with measuring the distance that could exist between two random individuals who do not know each other [MIL 67]. His idea was to establish the connections between individuals by asking them to deliver a piece of mail in person. At each step of the mail's distribution, indications written on the envelope made it possible to keep a record of the successive carriers. He then calculated the number of intermediaries necessary to connect people from Nebraska to a target person in Massachusetts. Milgram reported that the chains created varied in length between 2 and 10 intermediaries, with a median of 5.5. He therefore proposed that every person is contactable by any other individual by making an average of six leaps, thereby confirming the theory of the "six degrees of separation" proposed by the Hungarian author Frigyes Karinthy in a short story from 1929 called "Chains".

These experiments were recently challenged by Kleinfeld [KLE 02] who suggests that far from six degrees of separation, we live in a world that is strongly divided by social barriers. According to her, "At the core of the small world problem are fascinating psychological mysteries". In any event, with his extremely simple and appealing protocol, Milgram showed that it is possible to find an experimental measurement of the distance that can exist between two complete strangers, by counting the number of intermediaries necessary to establish a chain between the two of them.

This idea was later taken up in the context of more targeted populations, including mathematics researchers and Hollywood actors. In these cases, the connectivity between two people corresponds to the completion of a common task: writing a scientific article or appearing in the same film.

For the connectivity between mathematicians, the famous "Erdös number" serves as the basis for the distance measurement. The

Erdös number refers to the Hungarian mathematician Paul Erdös (1913–1996) who published more than 1,500 scientific articles, two-thirds of them in collaboration with one or more of his nearly 500 co-authors. Each of his direct co-authors was therefore assigned an Erdös number equal to 1. A person who had co-authored an article with a person with an Erdös number N was therefore assigned the Erdös number N + 1. By convention, Erdös himself has the Erdös number 0 and people not connectable to Erdös have an infinite Erdös number. To this day, the highest Erdös number is 15 and practically all of the great scientists have an Erdös number: Einstein, Nash, Fermi, Gauss, Bohr, Heisenberg, Dirac, Schrödinger, etc.

The "Bacon number" is an application of the same idea to film by placing a connection between two actors if they acted together in the same film. This distance refers to Kevin Bacon who was chosen as the "center" of this model and has a Bacon number equal to 0. Actors that have appeared in a film with him have a Bacon number of 1 and so on. The connectivity in the world of actors is very strong, because we estimate that only 12% of actors have an infinite Bacon number.

There is even a calculation for a "Bacon-Erdös number", by adding the two together. The number of mathematicians who have acted in a film is hardly larger than the number of actors who have published works about mathematics, but by intervening connections it is possible to join these two communities. For example, this is the case for Danny Kleitman, a mathematician from MIT who published with Erdös, and who, as an advisor for *Good Will Hunting* (1997), obtained a short appearance in this film in which Minnie Driver also acted, an actress who also acted in *Sleepers* (1996) with Kevin Bacon. Danny Kleitman has the privilege of having the lowest Bacon-Erdös number to date (3). And, unless Kevin Bacon himself publishes a work of mathematics (co-authored, of course, by a mathematician with an Erdös number of 1) or if he is given the lead role in a film about Erdös (in which several mathematicians who knew Erdös also act, of course), it is very unlikely that this record will be beaten.

A lot of ink, and even more bytes, have been spilled over this kind of proximity calculation between individuals. The website of the *Erdös Number Project* is http://www.oakland.edu/enp/. The website of the *Bacon number*, http://www.cs.virginia.edu/oracle/, uses data from the *Internet Movie Database* (http://www.imbd.com). The frenzy over this subject shows that the establishment of these social networks can generate all kinds of calculations. These networks also strengthen the myth or belief in the "six degrees of separation", which is very strong in the United States. An experiment about social distance measurements is currently being led on a very large scale (http://smallworld.columbia.edu/). This initiative intends to collect, from a maximum number of internet users, the social connections that relate them in order to be able to determine the length of the paths that connect people who do not know each other.

The underlying model of all of these social networks is a graph where each individual (the nodes) are considered in view of the social connections they have (the arcs). Starting from this graph structure, it is possible to calculate formal values such as the number of connected components in the graph (or in other words, the number of "islands" completely dissociated from one another), and for each of these connected components, the shortest existing path between two nodes (the path that mobilizes the least possible intermediary nodes), the diameter of the connected component (the largest of all of the shortest paths by considering all possible pairs of nodes), the average diameter, also known as the characteristic distance (the mean of all of the shortest paths by considering all possible pairs of nodes) or the center of the connected component (the point where the sum of all of the shortest paths that join each of the other nodes is the weakest) [HAY 00].

4.5.3. *Hierarchical small-world networks*

Based on a similar approach, recent studies have focused on other types of networks than strictly social networks: networks formed by weather stations, flight connections, phone connections, physical connections between computers that cumulatively make up the Internet, as well as by observing networks that occur "naturally", such as networks formed by the neurons of simple organisms, the spread of epidemics, complete web pages or specific sites, etc. In short, any type of observable network, whether it is produced naturally or generated by human activity, lends itself to this kind of measurement [GAU 04]. It is remarkable that all of these studies attribute similar properties regarding their diameter and the distribution of connectivity between their nodes to all of these graphs, despite their very diverse origins. There is a specific class for these graphs: hierarchical small-world networks (HSWN) [ALB 02].

To address the study of these HSWN, Watts and Strogatz established two study parameters: the distance between network nodes (global diameter of the graph) and the level of clustering (local clustering coefficient). As noted previously, these analyses can in fact only address one connected component of the graph (that is an island in the graph) and we are therefore only focusing on the largest connected component of the graph (that is the island that connects the most nodes). Consisting of "large" graphs, and very often by the very construction of these graphs, this main connected component is revealed to correspond to the entire graph: two airports are always joinable by a direct flight connection or by a succession of connections (even if these connections are inefficient, such as Paris-Orly -> Bordeaux -> Paris-Roissy, the fact remains that we can still get from Orly to Roissy by plane).

The first study parameter (the diameter) is based on the notion of topological distance between two vertices, a distance defined by the number of edges separating these two vertices, as defined above. The second parameter is developed using the ratio <number of edges present>/<number of edges possible> between the neighbors of a reference vertex. The mean of this ratio for all vertices on the graph is called the clustering coefficient. In their analysis, Watts and Strogatz proposed comparing the HSWN of random graphs and regular graphs [WAT 98].

A random graph is defined as a graph with N vertices connected by n edges chosen randomly with the probability p from among the $N \times (N - 1)/2$ edges possible. Therefore, this graph has $p \times N \times (N - 1)/2$ edges distributed randomly. The set of graphs with this number of edges is composed of all the possible combinations of graphs from among the $N \times (N - 1)/2$ possibilities. These graphs are all equiprobable. Their analysis demonstrates that in their probability space, they have a weak diameter, a weak characteristic distance and a weak clustering coefficient.

In contrast, regular graphs have regularly distributed vertices and each one of them is connected to its k closest neighbors. Here, "k" is the degree of connection between each vertex (an identical degree for each vertex). This type of graph has a large diameter because moving from a given vertex to the opposite vertex (furthest away) involves crossing n/k edges. A regular graph also has a strong characteristic distance and a strong clustering coefficient [HAY 00].

According to Watts and Strogatz [WAT 98], we can construct a "small-world" graph by situating ourselves mid-way between the method of constructing a random graph and the method of constructing a regular graph. They proved that small-world graphs have the property of being locally dense (like regular graphs) and have a relatively short path length (like random graphs). A "small-world" graph combines the properties of local regularity and global disorder. It seems that the graphs encountered when modeling world phenomena all resemble each other in their common structure, although this structure is very rare from a probabilistic point of view, that is, considering all of the combinations that we can create from a given number of nodes and arcs.

The HSWNs have more arcs than nodes; of course, all graphs have more arcs than nodes, but here it is 10 or 100 times more. With this large number of edges, we understand that some of them play the role of "short-circuits" within the possible paths in the graph. This property is found when we construct a network randomly. The characteristic distance, or average distance, is limited in the case of random graphs and "small-world" graphs by an upper bound of the order of the logarithm of the number vertices in the graph [HAY 00, ALB 02]. Even better, according to Albert and Barabási [ALB 02], we can approximate this measurement using this equation:

$$d \sim (\log(N)/\log(k))$$

where for a network composed of N nodes and L edges, k = (L/N) represents the average number of edges that belong to each node.

On a network like the World Wide Web, counting 10 billion accessible pages and an average of about 10 links per page, we have reason to expect a characteristic distance in the order of… only 10. And that is actually the value found by Adamic *et al*. in 1999. They suggested that the diameter of the web had a value of 19 [ADA 99] and that on average, only 10 clicks separated any given pair of pages, very low values compared to the billions of pages that compose it.

It is interesting to note the robustness of these values, notably the values of the "shortest paths" measured on these networks. By assuming that two web pages do indeed have a maximum of 19 clicks of separation, every mischievous Internet user immediately thinks of the idea of producing a chain, for example of 25 pages, uniquely intended to artificially extend the measurement given above. But if these pages are unknown by all, they are useless and do not change the face of the rest of the web, and if their existence is public, then there is a strong chance that another Internet user will decide to indicate another page in the middle of this chain, thereby breaking in two the slight length that was created.

Intuitively, the clustering coefficient on the World Wide Web is understood as the fact that when one page points toward two other pages, those pages have a strong chance of also pointing to each other, or at least much more of a chance than if they were randomly selected on the web. This property would not be found if the connections between pages were really random.

4.5.4. *Scale-free networks*

Working on the more general problem of constructing and organizing networks, Barabási [BAR 03] added a third metric relative to the hierarchical distribution of links in these networks. The growth observed on some small-world networks (like the web) shows a property of preferential attachment that cannot be modeled by simple average path lengths or the level of node clustering. This new property translates the fact that a new node will be preferentially placed in connection with nodes that are already themselves strongly connected. This more cumulative model produces a network where most of the nodes have few links and only some nodes have many links.

This property is validated by the distribution of the arity of nodes, or in other words, by the distribution of the number of vertices directly accessible from each vertex. This distribution follows a power law, as opposed to random graphs where the probability of having k neighbors follows a Poisson distribution. According to Barabási, the coefficient of this power law is a strong characteristic of the network. For small-world networks, we find values between 2 and 3.

Small-world graphs present on average a relatively short distance between any of their vertices (in the order of what we can find in random graphs), as well as a clustering rate at least equal to that of a regular graph. A power distribution law of degrees of connection between nodes is compatible with a strong clustering coefficient. Networks presenting this additional property are called “scale-free small-world networks” or “scale-invariant small-world networks”.

4.5.5. *Quantitative characterization of the usage graph of a corpus*

It is on the basis of this distribution of degrees of connection within a usage graph that we propose constructing the measurement of context in a knowledge corpus. Starting from a graph formed by the users of a knowledge corpus, and taking the representation of an existing connection (in the form of an e-mail exchange, for example) as a connection between two users, it is possible to characterize this graph by focusing on the distribution law of the degree of connectivity (arity) between different vertices.

The users of the corpus form a finite set of people (nodes). The relations these people have with one another form a graph (edges). It should be noted that although it is mostly undirected (that is composed of bidirectional links, because a sharing network is theoretically based on a symmetrical aspect of sharing), this graph can still contain directed arcs (asymmetrical): people in your address book have not necessarily put you in their own.

This graph, studied in the domain of social networks, has the characteristics of a small-world graph. Following what was noted previously, the probability distribution of the degree of connectivity between the vertices is a significant characteristic of the network.

If p(k) is the probability for a node to have k neighbors, the classic Poisson law gives:

$$p(k) \sim g \exp(-k)$$

For a scale-free graph, the law is simplified to a power law, characterized by its coefficient a:

$$p(k) \sim g\, k^{a}$$

We can therefore easily define and calculate the entropy for a scale-free network, because of the formula:

$$\mathrm{Val_C(H)} = -\sum_{k} p(k)\log(p(k))$$

This entropy, which has a simple form in the case of the power law, is a good characteristic of the usage network of a knowledge corpus. We will use it as a context measurement in the entropy of knowledge.

For the function $\mathrm{Val_C}$, the entropy of the knowledge usage graph provides the third function required to define the entropy of knowledge.

4.6. Practical application

The applications of the concepts stated in this chapter are innumerable.

Shannon's theory of information is the basis for our entire digital civilization, not only at a technical level (telecommunications and computing), but also at the level of dominant thinking (whether we look at the so-called "connectionism" model in psychology, where the brain is considered to be an information processing machine, or communication and learning theories, that constantly refer to Shannon's model).

There are many graph algorithms to extract meaning from information and a host of software exists on the market in highly varied domains: social science research, documentary corpus processing, monitoring, text analysis, etc.

The aspect that considers the context of interpretation is less clear. If we consider the aspect of the usage context on the web, there are many applications in the domain of telecommunications especially, but also in other domains, and the theory that is outlined here has its source there.

One of the most significant applications, which is certainly a flagship application in a knowledge society, is Google's *PageRank* © algorithm. This search algorithm operates on the web, which is not only a colossal information base, but also a knowledge source. The algorithm searches for knowledge in this base by applying three principles based on the semiotic triangle of knowledge.

– *First principle: information*

When a request is submitted to a search engine, the algorithm considers that it is information, a chain of characters, and that it is coded (ASCII code stands for American Standard Code for Information Interchange, or more generally the universal code Unicode). All of the information on the web is coded in the same way. The algorithm proceeds to match the chain of characters in the request and the chains of characters found on web pages. It recognizes the words in the request present in the web pages. It carries out some processing, which can be sophisticated, on the character chains (spelling adjustments, for example).

– *Second principle: meaning*

Recognizing the words of a request on a web page is not enough. For example, the requests "Blue card" and "A card that is blue" would be equivalent according to the first principle. The noun phrase "Blue card" has a specific meaning in the first request (for France; for the United States, we could say "Green card"), which is not true for the second request. The algorithm will therefore consider that the proximity of "card" and "blue" creates a semantic link, and prioritize searching for web pages where "card" is close to "blue". More generally, the algorithm will search for the co-occurrence of terms. Co-occurrence is the simultaneous presence of two or more words (or other linguistic units) in the same utterance. These words necessarily have some kind of linguistic link. When these words have a semantic relationship, the notion of co-occurrence defines a domain of meaning.

– *Third principle: context*

Google's *PageRank©* algorithm will account for context in its search of web pages. This algorithm is the source of the software's success. Its name, which is also a brand, is a word game invented by Larry Page, co-founder of Google, composed of the words "page" and "rank". It consists of attributing to each page a value (or score) that is proportional to the number of times that a user traversing the graph of the web would pass by this page by clicking randomly on one of the links appearing on each page. A web page is therefore considered to have a context value that is its usage context on the web.

Therefore, a web page that is extracted from the web by the Google algorithm has three values: an informational value, a semantic value and a contextual value. Although this algorithm is partly protected by secret, it is probable that it does not use, or very little, the entropic values defined in this chapter. However, it is not very far from this approach (Figure 4.8). We can say that Google is certainly one of the first tools that does not only process information, but knowledge.

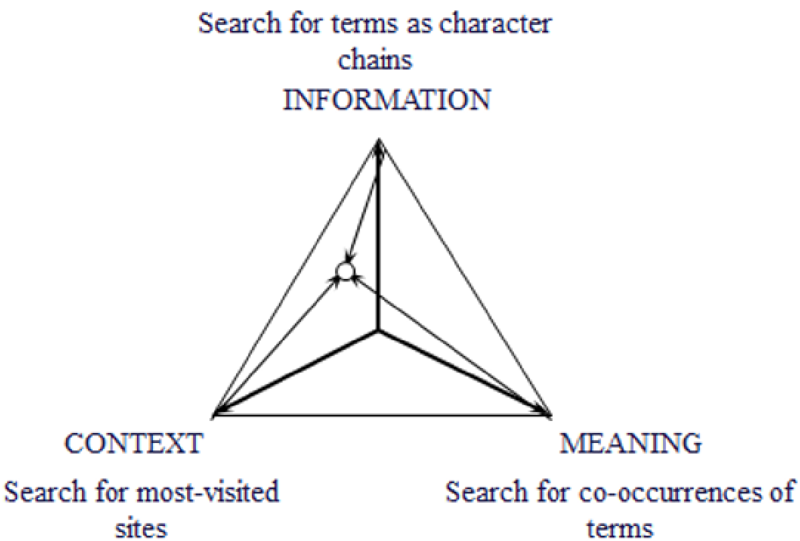

Figure 4.8. *Google's algorithm and the semiotic triangle of knowledge*

4.7. Conclusion

The growing importance of knowledge in our society as a "collective good" results in a certain dilution of this notion into several more or less vague concepts and its implication in several domains, including social, economic, scientific, technical, etc. Such concepts are for instance: knowledge society, knowledge management, knowledge engineering, etc.

This proliferation is similar to what happened more than 60 years ago for the notion of information. The engineer Claude Shannon developed a mathematical theory of information that revolutionized the field and had countless applications, as much for the technical aspects as for the conceptual aspects. The extension of such a theory to the concept of knowledge is now the order of the day.

The fundamental mathematical tool of the theory is entropy. If we know, because of Shannon, how to define the entropy of an information corpus, then what about the entropy of a knowledge corpus? If Shannon's entropy makes it possible to calculate the quantity of information contained in a corpus, can we find a measurement of the quantity of knowledge contained in a corpus in a similar way?

We put forth the very strongly justified hypothesis that knowledge is formed by three elements (information, meaning and context).

One elementary unit of information is traditionally represented by a "bit" (binary unit or digit) formed by 1 or 0. One elementary unit of knowledge (a "cogniton" represented by a "kit" or knowledge unit) will be represented by one elementary unit of information, one elementary unit of meaning and one elementary unit of context.

One elementary unit of meaning is formed by two "semes" (which are the traditional elementary units of meaning) related by a semantic link. This is the smallest element that can be used to construct a semantic network.

The notion of context is more problematic. It has not been the subject of advanced formalizations to our knowledge. We made the hypothesis of representing the context as the usage context. One elementary unit of context is represented by a set of two users of a knowledge corpus who are related to one another by a social connection.

A knowledge corpus can then be considered from three aspects. The first aspect is information. The informational aspect reduces the knowledge corpus to its underlying information corpus. Shannon's classic entropy provides the first measurement. The second aspect is meaning. Meaning is represented by a graph of semes constructed out of semes that are representative of the corpus. The possible paths in this semantic graph are the means of potential meaning in the corpus. The Gurevich entropy in this graph provides a measurement of these paths, which provides an entropy of meaning in a corpus. The third aspect is context. The usage network of a corpus has characteristic properties, notably the distribution of user connectivity. This makes it possible to define an entropy on the usage network of a knowledge corpus.

Therefore, we have three measurements for the information, meaning and context of a knowledge corpus. These three measurements are carried out by mathematical entropy.

The path has been laid out, but there is still much to be done. All of the measurements must be theoretically and experimentally validated. They must be refined and adapted, and likely a weighting of each of the different quantities, natures and values must be established. The reference systems and algorithms (calculations for semantic graphs and usage graphs) must be designed. Finally, processing the global entropy, synthesizing the three entropies, must be established.

PART 2

Practical Elements

5

A New Approach to KM

5.1 Introduction

Historically, companies have managed their knowledge and know-how by eliciting them in documents and processes, disseminating them (through training, for instance), organizing exchanges of all kinds with their collaborators, etc.

Now, in the "knowledge economy", a new dimension has appeared, which is the strategic dimension of knowledge, as a resource for competitiveness, performance and risk prevention. In a company, this requires a global, conscious and reasoned approach to manage its knowledge capital. It is a long-term project to be completed gradually through all of the Knowledge Management (KM) actions already implemented in the organization by expanding their scope of action and concentrating on strategic challenges. Increasing the added value of knowledge also requires thinking about innovation as being anchored in KM. It is also a cultural change that should appear gradually in daily work, and not as a revolution that must change everything. The implementation of KM in a company is a long-term action that must be considered to be an effort of continuous progress.

After nearly 20 years of maturing, KM has now entered into an operational phase. The objective of companies is now to plan, establish and maintain an effective program for KM. The examples provided in section 5.2 show that this option is essential.

Knowledge Management: The Creative Loop, First Edition. Jean-Louis Ermine.

5.2. Two examples of KM standardization

5.2.1. *KM and international standardization*

The *International Organization for Standardization* (ISO) is the largest standard-setting body in the world. It is a non-governmental organization that represents a network of national institutes from 165 countries and its goal is to produce international standards in industrial and commercial domains, called the ISO standards. These standards are used by all types of economic and industrial organizations as well as numerous other actors requiring international conformity.

> ISO/FDIS 9001:2015
>
> Section 7.1.6. Organizational knowledge
>
> The organization shall determine the knowledge necessary for the operation of its processes and to achieve conformity of products and services.
>
> This knowledge shall be maintained and be made available to the extent necessary.
>
> When addressing changing needs and trends, the organization shall consider its current knowledge and determine how to acquire or access any necessary additional knowledge and required updates.
>
> NOTE 1: Organizational knowledge is knowledge specific to the organization; it is gained by experience. It is information that is used and shared to achieve the organization's objectives.
>
> NOTE 2: Organizational knowledge can be based on:
>
> 1) internal sources (e.g. intellectual property; knowledge gained from experience; lessons learned from failures and successful projects; capturing and sharing undocumented knowledge and experience; the results of improvements in processes, products and services);
>
> 2) external sources (e.g. standards, academia, conferences, gathering knowledge from customers or external providers).

Box 5.1. *The ISO 9001 [AFN 15] standard for Knowledge Management*

Since 2015, the ISO 9001 standard has included a paragraph dedicated to KM (ISO DIS 9001 section 7.1.6). The requirements of the 2015 ISO version are well known by KM practitioners:

– identify the required knowledge necessary for business processes and conformity for products and services;

– maintain and disseminate the knowledge;

– identify how to acquire or access additional required knowledge.

As we can see, this standard lays the foundation for KM processes that should be implemented in companies. Notes 1 and 2 of the standard very generally outline the notion of internal knowledge capital and the relation with existent external capital. They do not really distinguish information from knowledge, and they allude to the concept of tacit knowledge. However, the introduction of a paragraph about "Organizational Knowledge" into international standards is a historical step for the recognition and implementation of KM in companies.

5.2.2. *KM in the nuclear domain*

Globally, the nuclear domain is very sensitive to the issue of preserving its knowledge capital. This field is particularly at risk of knowledge loss. It is a "knowledge intensive" domain, which means that it is based on abundant and complex knowledge and expertise notably due to its technical and scientific aspects.

Like in many other technical domains, a long-standing loss of interest of young generations toward scientific careers in general, combined with a long period of non-recruitment, has created a very serious knowledge gap, accentuated by the aging demographic affecting skilled people in that field.

The well-known safety and security and geostrategic constraints of the nuclear domain also add to the criticality of the risk related to knowledge.

The nuclear domain is experiencing an unprecedented renaissance, mainly in energy, for multiple reasons (increase in energy demands, the fight against climate change, etc.). The problem of knowledge is particularly acute at the level of knowledge preservation as well as its dissemination and evolution.

This problem is the focus of particular attention by international organizations in charge of the nuclear domain, notably the most important one: the International Atomic Energy Agency (IAEA). The IAEA, a UN organization, is at the center of international cooperation in the nuclear domain. The main goal of the IAEA is to promote the safe, secure and peaceful use of nuclear technologies among its member states. Its main governing body is the General Conference, led by the Board of Governors.

Regarding the problem of knowledge, given the importance of the issue, the General Conference in 2002 in Vienna voted on a resolution, which was reiterated during the General Conference in 2014.

> Nuclear Knowledge Management Resolution,
>
> General Conference
>
> June 17–19, 2002, Vienna
>
> (Excerpt)
>
> *If we do nothing we may be facing a situation by the end of the next decade in which the opportunity for a revival of nuclear power in terms of qualified personnel, safety, the expectations of developing countries and of our future will be lost together with knowledge and know-how built up over successive generations.*

Box 5.2. *Declaration of Mohamed El Baradei, General Director of the IAEA, 2002*

A *Nuclear Knowledge Management* (NKM) section was created within the IAEA to fulfill these missions. Since 2002, its program has consisted of:

– developing methodologies and guides to plan and implement KM programs in the nuclear domain;

– facilitating training, networks and the exchange of experience in the nuclear domain;

– assisting member states by providing products and services to maintain and preserve knowledge in the nuclear domain;

– promoting the use of cutting-edge KM technologies and supporting member states interested in using them.

> Effective decision making during design, licensing, procurement, construction, commissioning, operation, maintenance, refurbishment and decommissioning of nuclear facilities needs to be risk-informed and knowledge-driven. Nuclear technology is complex and brings with it inherent and unique risks that must be managed to acceptably low levels. Nuclear facilities may have very long life-cycles with changing operational conditions. Our ability to take safe decisions and actions is continually being threatened by the risk of knowledge loss. To ensure safety, we have a responsibility not only to

establish adequate technical knowledge and experience in our nuclear organizations but also to maintain it. This is the reason why nuclear knowledge management is so important.

Box 5.3. *Declaration by John de Grosbois, Section head of Nuclear Knowledge Management, IAEA, 2015 [GRO 15]*

Recently, KM was integrated into the safety standards. The IAEA's safety standards provide members states with basic principles, standards and guides to ensure safety in the nuclear domain. They reflect an international consensus on what constitutes a high level of safety to protect populations and the environment from the harmful effects of ionizing radiation.

These standards are officially recognized by member states, which can use them directly, and they are used as a reference for audits of national standards and as a benchmark for their compliance. They are not binding for members, but they can be adopted by them. On the other hand, they are binding for the IAEA's own activities and for states that want to be accredited by the IAEA.

KM is now recognized as a critical factor for safety in the nuclear domain, so it is natural to introduce this element into the safety standards, which did not mention it before. To this effect, a revision of the GS-R-3 standard: *The Management System for Facilities and Activities* was validated in 2016.

5.3. The French Knowledge Management Club

The French KM Club is an association that was created in 1999 and presided over by Jean-Louis Ermine until 2016 and by Benoit Leblanc since then.

Its founding members are PSA Peugeot Citroën, Microsoft, Cofinoga and the Bull/Osis group.

The French Knowledge Management Club very broadly gathers together companies from all sectors to contribute to *developing the attitudes, culture and actions of KM*. It is open to all companies, small or large, from all activity sectors, local or national authorities and public or private organizations.

Its objectives are:

– to develop cross-sectoral dialogue and debates between decision makers and experts;

– to help managers to situate their actions in relation to major developments in this strategic domain;

– to propose reflections, meetings, documents, etc. that make it possible to gather rich and general information in a very short time;

– expand and increase cooperation between all actors and extend networks.

The club's approach is practical. It consists of building concrete and operational elements that can instigate specific actions in companies. All of the work conducted in the work groups is to provide "deliverables" that are available and usable by all members. These products start from the experience of the members, and are intended to improve their practices. Little by little, the club has built a reference framework for KM that, after 15 years of development, covers a huge range of topics.

The club's commissions are evolving at the same time as the issue of KM is being refined. The main topics are addressed in it: company maturity, knowledge portfolio analysis, knowledge writing and transfer, communities of practice, innovation, web 2.0, the added value of KM, etc. This knowledge capital, which is the real wealth of the French KM Club, is constantly being enriched and restructured.

This knowledge capital is compiled in a document that is available to all. It is shared through a collaborative workspace. It is enhanced internally and externally by distribution tools, publications, seminars, training sessions and presentations, sometimes organized in partnership with other organizations. A virtuous circle of progress is implemented through the organization for feedback on the tools and concepts used in the club.

ADEXYS, ADOBE, ARDANS, AREVA, ATAO, CABINET PLENITUDES, CAISSE NATIONALE DE L'ASSURANCE MALADIE DES TRAVAILLEURS SALARIES, CEGOS, CEN/IPEN (BRAZIL), CENTRE NATIONAL DE LA FONCTION PUBLIQUE TERRITORIALE, CGEY, CHAMBRE DE COMMERCE ET D'INDUSTRIE DE PARIS, CHRONOPOST, CITE DES SCIENCES ET DE L'INDUSTRIE, CLIENTLOGIC, COFINOGA, COLLEGE DE POLYTECHNIQUE, COMMISSARIAT A L'ÉNERGIE ATOMIQUE, CORTECHS, DASSAULT SYSTEMS, DELEGATION ACADEMIQUE A LA FORMATION

CONTINUE, DIALOGIE, DIRECTION GENERALE DE L'ARMEMENT, DYNAXIS, EDF, ESSILOR, ÉTAT-MAJOR DE LA MARINE, FIDLY CONSEIL, FORMIRIS, HYDRO-QUEBEC (CANADA), IAE AIX EN PROVENCE, INSTITUT DE RADIOPROTECTION ET DE SURETE NUCLEAIRE, INSTITUT MINES-TELECOM, INSTITUT NATIONAL DE RECHERCHE EN SCIENCES ET TECHNOLOGIES POUR L'ENVIRONNEMENT ET L'AGRICULTURE, INSTITUT NATIONAL DE RECHERCHE ET DE SECURITE, INSTITUT NATIONAL DES TELECOMMUNICATIONS, IOSH, ISWA CONSEIL, KADRANT, KEOLIO CONSULTING, KNOWMORE, LESAFFRE INTERNATIONAL, MANN-HUMMEL AUTOMOTIVE, MARINE NATIONALE, MBDA, MEDIA.T, MICHELIN, MICROSOFT, MINISTERE DE LA DEFENSE, NOETIKA, OFFICE NATIONAL D'ETUDES ET DE RECHERCHES AEROSPATIALES, BULL/OSIS GROUP, PERFORMANSE, PSA PEUGEOT CITROËN, RADIO FRANCE, SANOFI PASTEUR, SERVICE PUBLIC FEDERAL BELGE (BELGIUM), SHARING KNOWLEDGE, SNCF, SONATRACH (ALGERIA), SYNETICS, TEREOS, THALES, UNIVERSITE DE POITIERS, UNIVERSITE PARIS-DAUPHINE, UNIVERSITE TECHNOLOGIQUE DE TROYES, VOIRIN CONSULTANTS, VOLVO

Box 5.4. *A (non-exhaustive) list of the companies and organizations that have participated in the work of the French KM Club since 1999*

To contribute to the global KM standardization movement that has recently come to light, the French KM Club has made available, since 2017, a complete methodological guide, including a *Handbook* defining a reference framework for the KM process with associated tools, case studies, training elements, etc. [CLU 17].

This *Handbook* is intended for companies and organizations that want to implement a coherent KM plan and manage it as such. It is a guide based on the club's extensive experience with companies, the tools created by it, the research conducted with specialized laboratories and the connection with the IAEA project mentioned above.

The *Handbook* of the French KM Club provided the substance for Part 2 of this book.

5.4. Conclusion

The goal of Part 2 is to provide guides to plan, establish and maintain an effective KM program. The focus is placed on the practical applicability of the directions provided, obtained by brief and concise descriptions of all of the relevant KM processes. In this part, the question of the use of KM methods to prevent risks to knowledge and the development of strategic knowledge is addressed.

A complete framework is outlined for the implementation of KM with a Methodology for Analyzing and Structuring Knowledge (MASK) approach. This approach is centered on knowledge and based on the company's knowledge capital. Other approaches can be considered, including approaches that are centered on process, human resources or information. These approaches are not contradictory with the one proposed here, and several synergies will become evident.

The People, Process, Technology approach is the dominant one in KM. However, it has the disadvantage of diluting the concept of knowledge in the approaches: Human Resources (People), Processes or Technologies. This can sometimes lead to shortfalls (such as managing knowledge with technologies that only manage information), confusion (such as confusing KM and competence management), strategic errors (such as only managing knowledge through operational processes), etc. The knowledge-based approach proposed here, aside from seeming like common sense when talking about KM, is based on the principle that a company possesses a unique intangible capital (knowledge capital) that is the basic source of its competitiveness, productivity and sustainability. It is therefore around this capital (which is not visible as such) that the specific management of the company should be organized.

The practical approach proposed here relies very strongly on the first part which provided the theoretical foundations. The choice was made to separate the two parts because they do not necessarily correspond to the same interests or the same audiences. A curious reader will easily be able to make the connection, already outlined in Part 1. The practical approach that is proposed here is not an ad hoc approach, only reflected through experience feedback, but a well-founded and structured approach based on validated theoretical considerations.

6

A Framework for Knowledge-based KM

6.1. Introduction

As macro- and microeconomics has developed in the world, the nature of companies has changed a great deal. In the past, a company was focused on two essential elements: manufacturing and labor in the Taylorian sense. Now, important indicators have appeared outside of these two points of view, such as customer relationships, information systems, competitive intelligence, quality, etc. New professions that are crucial for companies have appeared (procurement, marketing, etc.). Companies are now constantly reorganizing themselves in relation to their environments to respond to new economic challenges. For several years now, companies have enriched their process frameworks to reflect all these changes.

Knowledge Management (KM), as a company project, needs to connect traditional perspectives about core activities with these new requirements. Its goal is to organize the critical knowledge that is an essential resource for the production of goods and services, and the critical knowledge that came out of the increasingly challenging economic and competitive environment to work together in coherent processes. According to the basic premise formulated in this work, coherence is organized around the company's knowledge capital, to which the key processes must contribute, and through which they cooperate. This is what is called knowledge-based KM.

These key processes are organized according to the Daisy Model, described in this chapter.

Knowledge Management: The Creative Loop, First Edition. Jean-Louis Ermine.

6.2. The Daisy Model

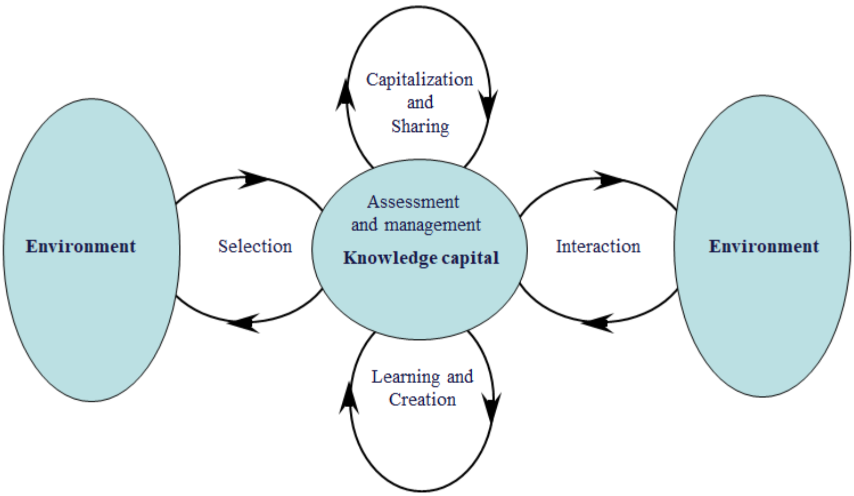

Figure 6.1. *The Daisy Model: The key processes of Knowledge Management*

Some processes that contribute strategically to the management of the company's knowledge capital are internal, such as capitalization and sharing or creativity and learning. Others are external, such as competitive intelligence or scanning, which must start from internal knowledge and feed back to it, or customer relations, marketing that acts as a filter on the immense potentialities of the creation and evolution of knowledge in companies.

KM is the management of these processes and the consideration of their relationship to the company's knowledge capital. We can describe them in four broad classes that correspond to the daisy's petals, and one class that corresponds to the center of this model:

– the process of capitalization and sharing knowledge. This is the one that achieves the virtuous circle of knowledge, and that ensures the sharing (the "recycling") of the knowledge resource in a company;

– the process of interacting with the environment. A system that is disconnected from its environment is a dead system. This is particularly true for knowledge, which is fed by increasingly important information flows that come from the company's environment. The process that transforms these information flows into knowledge capital that is useful for the company is complex. It is, among others, the process of scanning or competitive or strategic intelligence. Up until now, this mostly addressed the external information aspect, and not the interaction with the knowledge specific to the company;

– the process of learning and creating knowledge. This is an endogenous and collective process that is the foundation for the evolution of knowledge. It includes the issue of the "learning organization" and creativity;

– the process of selection by environment. This is an evolutionist process par excellence of selecting knowledge created based on market criteria, acceptability criteria, etc., that is both economic and sociotechnical. It includes issues of marketing, customer relations, etc. The problem with KM is integrating these types of issues into a strong relationship with the company's critical knowledge, especially professional knowledge, for instance;

– we can add a fifth process to this set, which is entirely internal to the knowledge capital, because it consists of the process of evaluating it all: qualitative evaluation, quantitative evaluation, financial evaluation or managerial evaluation for strategic management. More than a tool, evaluation is seen here as a true process, which requires a sophisticated implementation, follow-up and generates transformations within the organization.

The objective of Part 2 of this book is to define a set of coherent methods and tools to manage these processes and fully attain the objective of KM. The four petals of the daisy noted here are only a point of departure. If we go into more detail, we can separate them into several other petals. Implementing a KM policy consists of "plucking the petals off the daisy".

It should be noted that none of these processes are absent from organizations, in one form or another, intuitively or formalized, in simple or sophisticated forms. KM, fortunately, has always been present in companies. What is new is its generalized and strategic aspect, due to its new challenges, and the desire to create cooperation toward a common objective between activities that have until now been perceived as disparate and often peripheral to the company's business. To caricature the situation, we can entrust the capitalization process to a documentation service, even archives, the sharing process to an IT services, the interaction process to an environmental scanning service, the learning process to a training service, the creation process to an innovation service and the selection process to a marketing service. These services may very well never talk to each other and work on the company's affairs daily without direct contact. Alas, it would seem that this case is not just a caricature.

6.3. Building a KM process framework

The Daisy Model identifies the fundamental processes that participate in the management of the company's knowledge capital. To constitute the sustainable KM system of a company, this set of processes must be completed and organized. It is therefore possible to constitute a coherent KM process framework to be integrated with other company processes.

We will give an example of such a reference framework here. It is structured around eight fundamental processes:

– P1: evaluating and managing the knowledge capital

This process examines the state of the company's knowledge capital with regard to its content and control.

– P2: maintaining the knowledge capital and ensuring its application

This process ensures that the knowledge capital is maintained and applied.

– P3: managing and supervising knowledge acquisition systems

This process ensures the growth of knowledge and recruitment.

– P4: supporting creative systems

This process is knowledge based and called Knowledge-Based Innovation (KBI).

– P5: supporting design processes

This process supports knowledge-driven design in the company.

– P6: transforming external information into knowledge for the company

This process ensures connections with all kinds of environmental scanning processes.

– P7: implementing KM process tools

This process establishes an information system and its appropriate uses.

– P8: monitoring the KM system

This process ensures a sustainable system and the loop of progress that governs its evolution.

P1: Evaluating and managing the knowledge capital

P1.1: Assessing the knowledge capital

Subprocesses

- Analysis of the knowledge value chain

- Financial analysis of the knowledge capital

- Strategic knowledge analysis and needs analysis

P1.2: Managing the knowledge capital (relevance and quality of content)

P2: Maintaining the knowledge capital and ensuring its application

P2.1: Formalizing and making knowledge available

Subprocesses

- Eliciting tacit expert knowledge

- Formalizing operational knowledge

- Sharing knowledge (collaborative work, social networks, etc.)

P2.2: Ensuring knowledge application

P2.3: Selecting company's knowledge according to its environment

Subprocess

- Updating customer knowledge (Customer Knowledge Management or CKM)

- Knowing usages within the market (Usage-Assisted Design)

P2.4: Managing knowledge communities and expertise

P3: Managing and supervising knowledge acquisition systems

P3.1: Managing and supervising individual learning systems (training, e-learning, apprenticeship, etc.)

P3.2: Managing and supervising collective learning systems (expert groups, seminars, learning communities, etc.)

P3.3: Recruiting based on the needs of the company's critical knowledge

P4: Supporting creative systems

P4.1: Supporting the innovation process

P4.2: Supporting the creativity process

P5: Supporting design processes

P5.1: Initializing the design process based on the company's knowledge capital

P5.2: Using and sharing the knowledge necessary for goods and services design

P5.3: Reviewing the knowledge acquired during the design

P6: Transforming external information into useful knowledge for the company

P6.1: Managing and supervising environmental scanning systems (competitive, strategic, technical, etc.) in connection with KM

P6.2: Organizing the collection and collective interpretation of information from the external environment

P7: Implementing tools for KM processes

P8: Monitoring the KM system

P8.1: Defining the KM strategy and objectives

P8.2: Defining a KM plan

P8.3: Evaluating the KM system (reviews, indicators, etc.)

P8.4: Supervising the KM system (decision-making process, management process)

P8.5: Defining the progress actions for the KM system

Box 6.1. *A reference framework of KM processes based on the Daisy Model*

The example in Box 6.1 shows how we can establish a process nomenclature for a KM plan in a company. Because every company is unique and has a specific level of maturity in managing its knowledge capital, such a framework of processes must be customized, but the principles remain the same if we are concerned about implementing processes that effectively manage a company's knowledge capital. A more in-depth study of the Daisy Model was conducted in [ERM 03].

6.4. Conclusion

A KM plan implemented in a company must necessarily translate into the establishment of processes. The processes that we can identify as "managing knowledge" are countless. We could even say (and some do!) that any process in a company is a KM process.

In this way, it is very difficult to defend a KM strategy, to implement an appropriate structure and to have coherent monitoring tools. It is therefore necessary to have a reference perspective that makes it possible to get matters in order and act. The strong hypothesis that underlies all of the propositions stated in this book, namely that KM is the management of a company's knowledge capital, provides a filter that makes the task easier. A process is included in the KM framework if we can identify (and evaluate) its added value for the knowledge capital. Specifically, we can already observe if it uses knowledge capital and if it enriches it, in one way or another.

The Daisy Model is a proposition to provide an inclusive framework and build a framework of KM processes to implement and manage in a company. For a certain number of them, there is nothing new, except perhaps a different point of view concerning their objective and management. For others, it is a truly innovative process that requires an implementation that is often out of the ordinary and always on a considerable time scale. The following chapters will study some of these processes.

7

KM: From Strategy to Implementation

7.1. Introduction

Starting from the beginning, the point of departure for any Knowledge Management (KM) project in a company is to elaborate a KM strategy that normally includes elements such as:

– the objectives;

– the roles and responsibilities;

– the schedule and internal/communication;

– the resources;

– the connections between KM and other company processes;

– the connections with local, regional and international contexts;

– etc.

It is therefore important to specify the framework in which the KM project will unfold in the company ("KM Framework"), which will determine the strategy to adopt and guide the project management.

Once the framework is established, the design of a KM plan that will carry out the strategy must respond to a certain number of fundamental questions such as:

– What are the strategic and crucial knowledge domains for the company?

Knowledge Management: The Creative Loop, First Edition. Jean-Louis Ermine.

– What KM processes are necessary to reduce the criticality of different domains?

– What knowledge resources does the company have? How are they organized or structured? What resources are missing?

– How will the KM processes implemented ensure the evolution of constant progress in the knowledge capital of a company?

7.2. Framing a KM project

– Process P8: Managing the KM system

Complex organizations rely heavily on knowledge, and their activities depend on the availability and good management of this knowledge. The application of systematic KM practices in organizations is necessary to maintain the skills and competences required to reach a high level of performance. This is why these organizations must implement a complete KM system as an entirely integrated system.

KM is addressed here as a component in an integrated management system. Consequently, a prerequisite condition for any strategic KM plan in a company is to establish the framework of the KM project.

A certain number of subjects must be addressed in the framework phase.

7.2.1. *The objectives*

Top management must formulate the expectations for the company and participants in order to develop a strategic vision of knowledge and concentrate on the central question of knowledge.

The objectives expressed can pertain to the following points:

– creating a common culture for sharing knowledge;

– identifying the needs of new knowledge and the best acquisition strategies;

– identifying key knowledge;

– constructing and maintaining the company's memory;

– contributing to the effectiveness of the activities and methods based on knowledge;

– promoting learning (means of acquiring knowledge) by relevant systems;

– organizing knowledge sharing;

– ensuring creativity;

– constructing knowledge networks inside and outside of the organization;

– constructing a KM network within the organization.

Top management must support KM initiatives and communicate with all levels of the organization without leaving any space for ambiguity: the entire company must know that KM is an essential objective.

7.2.2. *Responsibilities and roles*

The successful implementation of a KM program depends on well-defined roles within the company. In many cases, these roles can be assigned to existing personnel. In large organizations, dedicated positions must be created, especially for the knowledge supervisor and knowledge managers.

– The highest-level role is that of the Board of Directors, or a KM director committee at this level. The Board of Directors ensures alignment with the goals and objectives of the organization. They meet regularly or at important points in the program.

– The Chief Knowledge Officer (CKO) is responsible for establishing the KM strategy. This person identifies the appropriate resources to elaborate, implement, monitor and assess the KM plan. The CKO reports directly to the Board of Directors.

– In large organizations, KM program managers called Knowledge Managers can be appointed in addition to the CKO. They are responsible for the daily management of the KM program in their unit. Knowledge Manager is a leading role, with the strategic responsibility of promoting KM, determining and allocating resources, and implementing, assessing and improving the program continually. A Knowledge Manager can also facilitate an internal KM community of practice.

– In every organizational unit, a KM coordinator can be appointed. It is his/her responsibility to ensure that KM activities are implemented in the unit in question.

– All employees are responsible for KM activities in their respective work area, in particular to maintain a culture of knowledge sharing and capitalize on the knowledge they produce. These responsibilities must be part of their work plans and job descriptions, in line with the KM strategy and the company's KM plan.

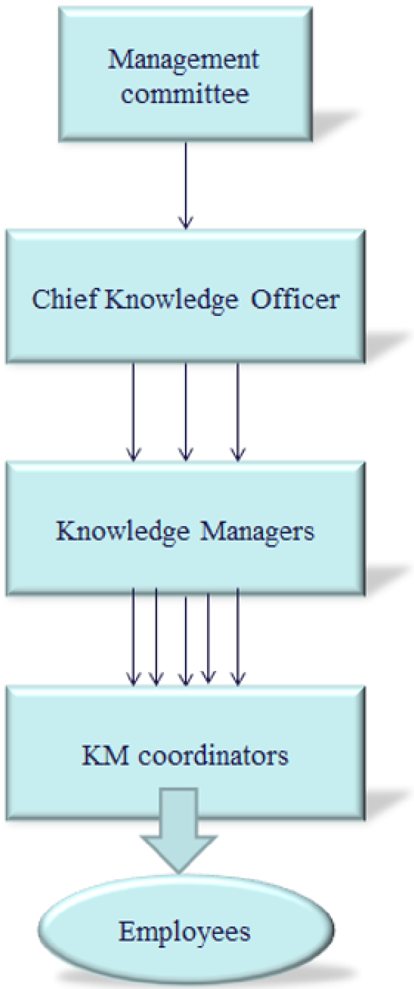

Figure 7.1. *The roles in a KM organization*

7.2.3. *Resources*

There are three types of resources:

– resources dedicated to cross-disciplinary KM projects. They are attributed to the CKO for specific projects (company knowledge server, deployment of KM methods, knowledge communities, pilot projects, etc.);

– resources allocated directly to the units or specific teams for specific KM projects included in the company's KM plan. Units distribute them to KM projects directly related to these units;

– resources to support general KM projects (software development, educational engineering, information retrieval, documentary support, etc.).

7.2.4. *Internal communication*

As is always the case for a strategic project, communication is essential. It must accompany a progressive development of KM by the company, starting from pilot projects, quick wins, identifying motivated units and gradually disseminating messages (through presentations, training, seminars, etc.) that can focus on topics such as:

– the advantages of sharing, capitalization, etc.;

– modifying personal attitudes;

– recognizing the value of knowledge;

– involving people in the knowledge processes.

7.2.5. *Connections between KM and other company issues*

Very quickly, KM, which is an encompassing issue, must be coordinated with several other elements already present in the company, and this can cause a certain number of problems. KM has strong connections with other issues and it is important to show how those issues can benefit from the contribution of KM. Here are a few examples.

– Human resource plans:

- input for a provisional plan for jobs, in particular when new activities are integrated into the company;

- input for training units and/or corporate university;

- input for professional tracks;

- specific KM criteria in individual assessments (sharing, capitalization, transfer, etc.).

– Information and communication technology systems:

- integrating KM tools in the global information system (knowledge servers, knowledge modeling tools, etc.);

– Risk assessment (knowledge risks):

- knowledge loss;

- knowledge gaps;

- knowledge clash.

– Organizational units and operational processes:

- defining operational knowledge to be managed directly by the operational unit;

- integrating knowledge into professional processes.

– Documentation and archives:

- accessing information and documentary resources;

- role of archiving in KM processes;

- creating books, doctrines, guides, etc.

– Company development plan:

- integrating KM in the process framework;

- indicators and reports from top management.

– National context:

- integrating KM into national standards;

- potentially changing policy directives;

- institutional cooperation;

- roles of different parties involved.

– International context:

- integrating KM into international standards;

- integrating international KM networks.

7.2.6. *Other subjects of interest to consider*

Implementing a KM project on a large scale requires a cultural shift that can change certain well-established practices in a company. Some subjects that were previously not related to KM may require particular attention. Here are a few examples.

– *Intellectual property*

Contracts with employees can be modified to distinguish between "knowledge holders" and "knowledge owners". To facilitate knowledge sharing between knowledge actors, the elicitation of expert knowledge, etc., the status of knowledge can be clarified by different means of intellectual property: licenses for knowledge use, copyright, "Creative Commons", etc.

– *Information security*

New ways to collect, disseminate and share knowledge are used in KM projects: recording interviews, films, sharing via networks, digital data collection, etc., and this can cause new problems regarding information security. These problems must be identified and discussed as soon as possible and preferably before the KM projects begin.

– *Respect for private life*

KM encourages the expression of personal opinions and free discussions. Confidentiality must be preserved in this context.

7.3. Implementing the KM project

– Process P8: Managing the KM system

- P8.1: defining the KM strategy and objectives;

- P8.2: defining the KM plan.

The knowledge-based approach proposed in this book is implemented with a four-step cycle, called the virtuous circle of KM, illustrated by Figure 7.2.

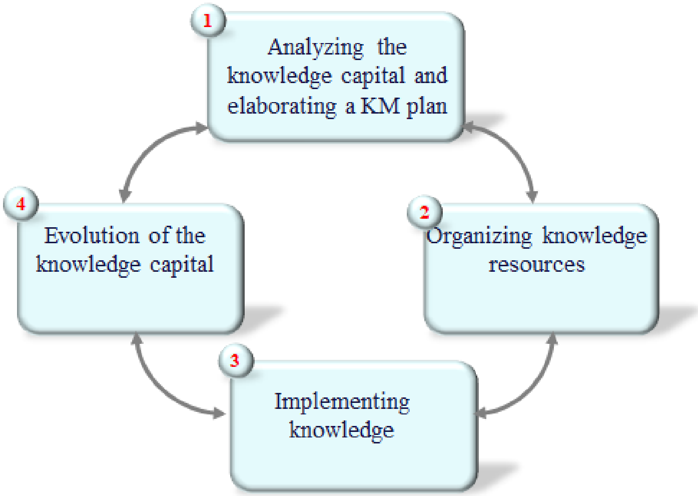

Figure 7.2. *The virtuous cycle of KM*

– Step 1: Analyzing the knowledge capital and elaborating a KM plan

Because a company's knowledge resources are major assets, focusing on this capital and maximizing its potential are essential conditions for developing and attaining sustainability. However, these resources are vulnerable and can be threatened, for example by knowledge loss (mainly a substantial loss of tacit knowledge). Consequently, it is essential to provide for the preservation, transfer, evolution and creation of knowledge throughout the company's activities and its interactions with its environment. The KM plan must be designed and integrated as a strategic process of the company.

The construction of a KM plan requires answering the following questions:

– What knowledge domains are essential for the company?

– Are they strategic?

– What are the main threats and risks involved in these domains?

– Who possesses this knowledge?

– What operational actions are possible and relevant for managing this knowledge?

– How can we ensure the alignment of the action plan with the strategic objectives of the company?

To answer these questions, it is necessary to analyze the company's knowledge capital guided by the strategy defining the company's missions. Proposing a KM action plan for preservation is then accompanied by the objective of sharing and developing knowledge in line with this strategy.

To do this, the first step requires strategically analyzing the knowledge capital, whose objective is to identify the critical knowledge domains in the organization and the appropriate actions to reduce their criticality. The KM plan is constructed on this basis, by identifying the KM processes necessary for each knowledge domain.

– Step 2: Organizing knowledge resources

For the critical knowledge domains identified in the first step, we can identify a large range of knowledge resources, hence the need to put them in order and establish how they should be organized and structured.

The first type of resource is codified knowledge, including databases, information and documentary resources, software resources, web resources, etc. The second type of resource is non-codified knowledge, including tacit knowledge: unwritten expert and specialist knowledge, knowledge communities (for example communities of practice), networks, etc.

Normally, this enormous knowledge corpus is dispersed in various areas, tacit knowledge is not sufficiently explicit, connections between knowledge blocks are often missing, etc. There is no complete view of the knowledge corpus (tacit or explicit) associated with each knowledge domain and it is far from being easily accessible. It is difficult to map the resources, design a coherent framework to facilitate their organization, allow for their maintenance and ensure their availability. This often involves adding new knowledge resources and tools to this framework.

– Step 3: Implementing KM processes

The next step consists of organizing the use of knowledge resources in the daily work of actors: how can they share, transfer, acquire, etc. their knowledge in order to be effective in their operational or decision-making tasks? To the extent that professional processes are implemented to support operational activities, KM processes must be implemented to support knowledge use in these professional processes, as required by the KM plan.

– Step 4: The evolution of the knowledge capital

The end goal of KM is to transform a company into a creative organization. Therefore, the ultimate goal of KM processes is to encourage innovation. KM develops the company's capacity to strategically develop all of its knowledge resources by creating new adapted knowledge. For this, KM must use all of the resources created in the previous steps to encourage the evolution of company knowledge. Moreover, it is necessary to ensure that KM continues to concentrate its efforts on the correct resources and thereby remain relevant. A good way to do this is to implement a mechanism (survey, follow-up, evaluations, etc.) to measure the way in which knowledge is used and how it benefits the organization.

7.4. Monitoring the KM system

– Process P8: Managing the KM system

- P8.3: evaluating the KM system (reviews, indicators, etc.);
- P8.4: supervising the KM system (decision-making process, management process);
- P8.5: defining the actions of progress for the KM system.

Process P8.4 is intended to maintain the KM system sustainably. This means monitoring it and managing requests for changes based on the company's needs. It must be based on a KM road map and divided into phases and an action plan. The KM road map describes the allocation of necessary resources, decision-making processes, regular reviews to conduct (type of review, domain, and date) and reports to complete. Process P8.3 provides different types of reviews and usable indicators given by the KM plan, which is conducted annually.

The phases and action plan describe the improvements necessary in the KM system. It can consist of providing KM training courses, broadening the best practices, developing new tools or improving existing ones, capitalizing on new expert and specialist knowledge, etc. These are elaborated during an annual decision-making review of the KM system. Process P8.5 follows system improvements.

7.5. Conclusion

Elaborating a KM strategy requires particular attention. Messages of knowledge sharing, capitalization, transfer and renewal are not always priorities for companies, but motivation in this area is essential. Moreover, KM requires specific roles that must be assigned and supported. Finally, a KM system is a global system in a company, which necessarily has connections with all other systems in the organization, and therefore must not be in conflict with them, but in synergy, which requires a great deal of attention.

Elaborating a KM action plan should first consider the company's existing knowledge capital. For this, it is necessary to proceed with a strategic analysis of this capital to determine the set of knowledge domains that are strategic and to analyze the threats and opportunities related to it to focus on the most crucial domains, and to design KM processes that are likely to reduce this criticality. Finally, this KM plan must be linked to a perspective of continuous progress that leads the company's knowledge capital to evolve in order to transform it into a creative organization.

8

Analyzing Knowledge Capital and Elaborating a KM Plan

8.1. Introduction

– P1: Evaluating and managing the knowledge capital

- P1.1: Evaluating the knowledge capital

Strategic knowledge analysis and needs analysis.

- P1.2: Managing knowledge capital (relevance and content quality).

– P8: Monitoring the knowledge management (KM) system

- P8.2: Defining a KM plan.

Once the KM framework has been defined, elaborating a KM plan requires accomplishing the following tasks:

– Task 1: constructing a map of objectives;

– Task 2: constructing a map of knowledge domains;

– Task 3: evaluating the criticality of the knowledge domains;

– Task 4: strategic alignment and decision-making for the KM plan.

The organization of tasks is described in Figure 8.1.

Knowledge Management: The Creative Loop, First Edition. Jean-Louis Ermine.

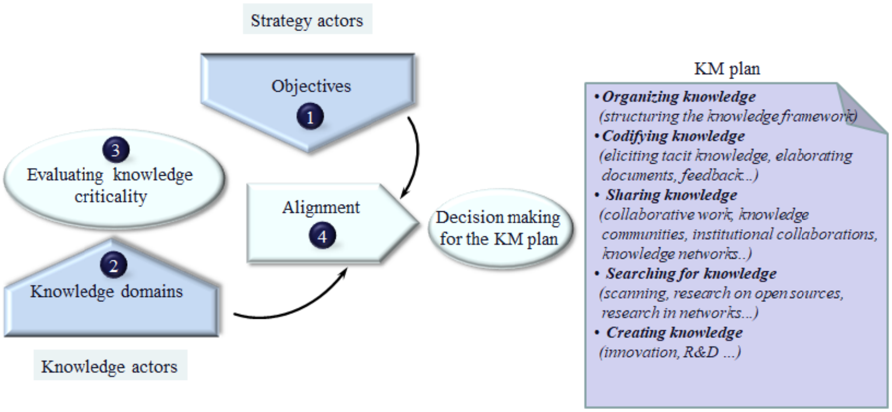

Figure 8.1. *Elaborating a KM plan*

8.2. Tools for analyzing knowledge capital

8.2.1. *Maps*

The knowledge capital analysis is based on the representation by actors of the objectives of their work unit and of the knowledge available in this unit.

The selected method of representation is mapping. Mapping is a process of abstraction that involves selection, classification, simplification and symbolization. When we want to represent our thoughts, experience or knowledge, we can construct a metaphorical map that adequately represents something that is by nature invisible and intangible as visible, concrete and significant. Therefore, in a general sense, elaborating a map is the transcription of a set of data into a graphic system, the processing of these data in order to reveal the information in the set in question, and the construction of images that are the best suited to communicate this information. The approach proposed here for a strategic analysis of knowledge capital uses representations in the form of maps built on these principles, which have been validated by ergonomics studies.

To construct a map, there is a very common and fairly old approach that is called *Mind Mapping*[1] [LEB 07]. This is the domain of representations that we call *Mind Maps* or mental or heuristic maps (or incorrectly, cognitive maps). It is an approach that makes it possible to graphically visualize mental representations that an individual or a group of individuals makes about a problem. It is a tree type of representation that is constructed recursively from a root node (the main subject of the map), and by constructing increasingly detailed branches, it gradually elicits the different elements attached to the parent node. It is a visual and symbolic way to "simply" represent a complex problem. A mental map is generally enriched by different elements that improve its use: forms, colors, graphics (illustrations, symbols), annotations, etc., which theoretically allow for easy comprehension.

In the knowledge capital analysis, we will use two maps: the objectives map and the knowledge domains map (or knowledge map).

8.2.2. *The knowledge criticality analysis grid*

The criticality of a knowledge domain is defined as an evaluation of risks/opportunities that the domain presents for a company. For example, a domain may have a risk of knowledge or know-how loss that can have harmful consequences, or it may have an interest in developing a domain to obtain benefits or advantages for the company (productivity gains, market share, etc.), or it may have difficulties capitalizing on and transferring knowledge, etc. Therefore, this step consists of "objectively" defining the criticality of a knowledge domain and providing an evaluation method that makes it possible to identify the most critical knowledge domains.

The criticality is identified using factors that are not necessarily easy to recognize. Criticality factors can be diverse, and very dependent on the culture and situation of a company. We can also attempt to be more or less relevant or exhaustive when elaborating criteria depending on the importance of the KM project in play.

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1 Tony Buzan became famous all over the world by creating and developing the concept of the Mind Map. He wrote more than 100 books, published in 150 countries and 30 languages.

Generally, we distinguish two types of criticality criteria:

Topics	Criteria
Rarity	1. Number and availability of holders 2. Externalization 3. Leadership 4. Originality 5. Confidentiality
Utility for the company	6. Harmony with the missions 7. Creation of value for the parties 8. Emergence 9. Adaptability 10. Use
Difficulty capturing knowledge	11. Difficulty identifying sources 12. Mobilization of networks 13. Tacit nature of knowledge 14. Importance of tangible knowledge sources 15. Rapidity of obsolescence
Difficulty using knowledge	16. Depth 17. Complexity 18. Difficulty of appropriation 19. History of the knowledge 20. Dependency on the environment

Table 8.1. *Critical knowledge factors (CKF)*

– *Factual factors*

These are factors that assess the very nature of knowledge, without *a priori* being concerned with the content of this knowledge. There are factors intuitively speaking, now fairly classic, that make it possible to qualify knowledge. These factors are divided into two classes: one evaluates the added value of the knowledge in terms of rarity and utility for the company, and the other evaluates the difficulty of exploiting the knowledge in terms of the difficulty of acquisition and the difficulty of implementation.

– *Strategic factors*

These are essential for a criticality study. They describe the concordance of the knowledge under consideration with the strategic missions or objectives of the organization as well as the consistency with the objectives of each unit. Knowledge may be complex, rare and fragile, but it may not be critical if it is not in line with the objectives. The strategic factors are of course particular to each organization. They must be established carefully, together with management at the highest level of the organization. In particular, they concern the positioning of knowledge in the strategic framework of the company and its environment, and in relation to customer needs and the objectives of the company's units, the capacity of knowledge to be valued by political, societal, and economic actors, etc.

Topic: Rarity
Factor 2: Externalization

What are the other actors in this knowledge domain and what is the complementarity of accomplished work? Are they the only ones working in this domain? Can this work be outsourced?

Level 1: Externalizable activity
The domain can easily be outsourced. Other organizations know the domain and can complete tasks in this domain.

Level 2: Common activity
The domain is practiced by other organizations but it is difficult to outsource.

Level 3: Specific domain
The domain is rare and specific. Few organizations work on this domain.

Level 4: Exclusivity
The company is the only organization that has competence and know-how in this domain. It is not possible to outsource this domain.

Figure 8.2. *An example of critical knowledge factors and their rating scale*

Table 8.1 gives an example of a generic grid of critical knowledge factors (CKF) that was developed by the French KM Club. The CKF library has 20 factors grouped into four major topics. Each factor is evaluated on a scale of 1–4 representing the realizability of the factor. To facilitate the analysis and notation, the levels of each factor are described succinctly. This consists of a rating description and not a normative description. Each factor evaluation is based on a question. Each level is expressed by a clear and general phrase avoiding vague terms that can lead to confusion (see an example in Figure 8.2).

8.3. The knowledge capital analysis process

The knowledge capital analysis process is an audit of a company's knowledge in order to construct a KM action plan to manage this capital. It must be conducted carefully in order to ensure the success and sustainability of the company's KM project. The approach described here is complete and exhaustive. Depending on the needs and means available, it can be simplified and it must be adapted to the context. For example, it often happens that this approach is concentrated on step 2 (analyzing critical knowledge).

8.3.1. *Step 1: analyzing critical capacities*

To simplify, we will define capacity as a collective capacity that integrates a set of individual competences to reach the strategic objectives of the organization. The analysis of critical capacities consists of identifying and qualifying the capacities required by the company to carry out its missions and reach its operational objectives.

To do this, we must first identify the objectives that the company (or the company unit) in question wants to achieve. The objectives map is a clear and simple representation of the strategy of the company or unit concerned. It formulates the missions in the form of objectives to be completed by the organization. First, it is completed using documents evoking the company's strategy, when they exist, identified during a framework meeting. Then, it is completed and validated by some strategic actors. This includes people who are deeply involved in developing the company's strategy, such as unit directors or members of the management committee.

An objectives map is a tree of strategic topics, objectives and subobjectives, with a limited number of topics (usually four to six). Each topic is divided into several objectives and each objective can be broken down into several subobjectives. The example in Figure 8.3 features a (fictitious) air cargo company.

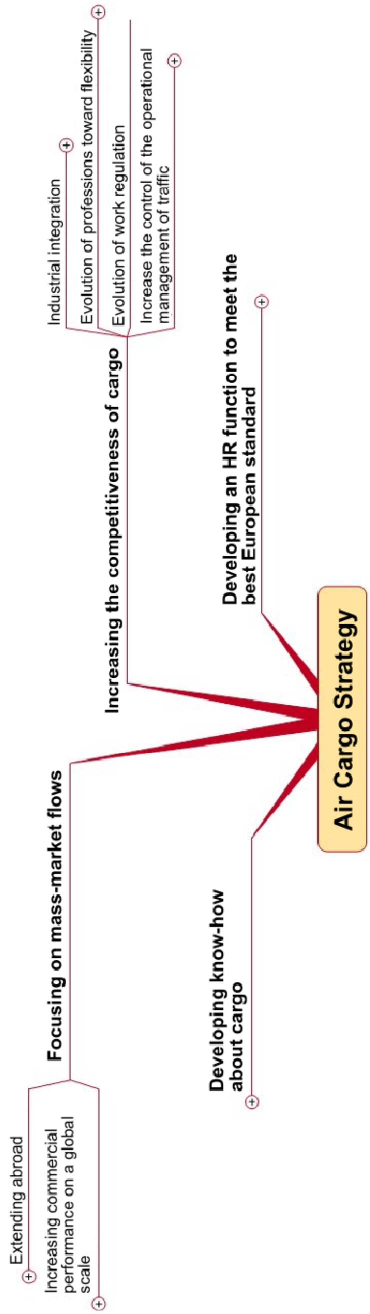


Figure 8.3. *Objectives map for an air cargo company*

The next phase is to identify and qualify the capacities required for the company to reach the capacities presented in the map. To do this, a team of people contributes individually or as a group (during a seminar, for instance). It consists of a small number of people who generally participated in the construction of the map.

The map is presented to the actors and used as a mediation tool. Once the map has been entirely covered, the people are asked to consider the topics one by one and indicate the capacities to mobilize in order to reach the objectives under consideration topic by topic and based on their own perception. At the end of the interview, each of the capacities identified is classified qualitatively by its level of criticality (is this capacity very critical, somewhat critical, or not very critical?) based on, for instance, the topics described in the CKF grid (Table 8.1): a capacity is more or less critical depending on whether it is more or less rare, useful for the company, difficult to acquire, or difficult to implement. At the end of each interview, a synthetic table of the evaluations and arguments is completed and then submitted to the relevant people for validation.

When all of the evaluations are completed and validated, a synthesis is carried out to eliminate redundancies, standardize formulations, group and classify capacities, and summarize arguments. These capacities, classified and argued, are represented on the objectives map. Each capacity is assigned a criticality coefficient that is elaborated using the criticality evaluations completed during the interviews. Symbolically, a capacity is represented in red, orange or green based on its degree of criticality. An example is provided in Figure 8.4.

8.3.2. *Step 2: analyzing critical knowledge*

Analyzing critical knowledge consists of identifying and qualifying different knowledge domains present in the company. To simplify, we will define a knowledge domain as a corpus that is perceived as homogenous, which groups together the people completing one or more activities that are characteristic of the company, a set of documents, or tacit knowledge and know-how, constituting the company's "knowledge network".

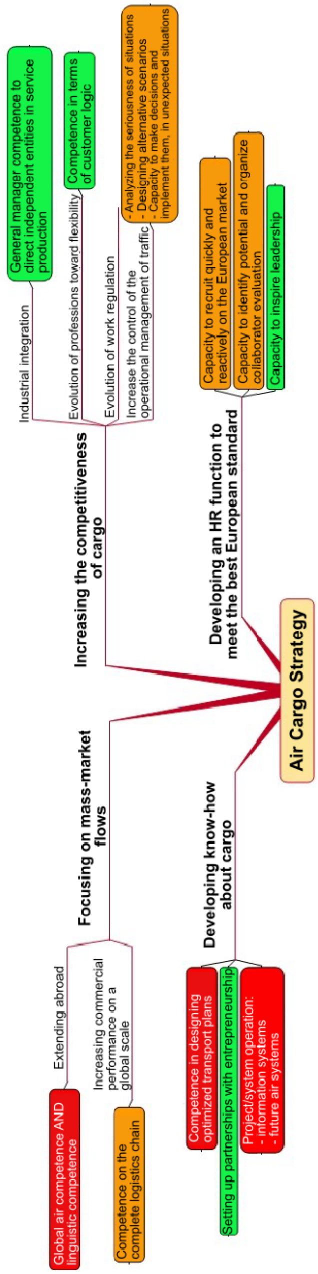


Figure 8.4. *Map of critical capacities for an air cargo company. For a color version of this figure, see www.iste.co.uk/ermine/knowledge.zip*

The first phase of the critical knowledge analysis is the construction of the knowledge domain map (or knowledge map). This starts by identifying these domains. Starting from the documentation of references and interviews, the identification consists of detecting knowledge domains through the successive analysis of activities, projects, products, etc. The format of the map must be adapted to the operational vision of the people concerned. This map will serve as a support for the interviews to evaluate the criticality of the knowledge domains.

Next, for each knowledge domain, referents must be designated, who will be questioned to analyze the criticality of their domain. This step can prove difficult, especially in large organizations. The credibility of the analysis in effect relies on the legitimacy of the people who are interrogated. Because a knowledge map can be very detailed, it is necessary to choose a level of granularity for the map that does not require too many interviews.

The criticality analysis always takes place with a criticality grid, such as the CKF grid shown.

Evaluating the criticality of a domain consists of assigning a score based on each factor for each domain. The more critical the domain, the higher its score is. Each domain is evaluated independently of the others based on the chosen factors. The principle can make the implementation relatively cumbersome based on the number of domains and factors used and if there are several evaluators. That is why the documents used must facilitate the task of evaluation. Two documents are prepared with this in mind:

– a simplified document for each knowledge domain. Its goal is to provide, as an overview, a qualitative evaluation of the criticality of the domain by summarizing the arguments and the potential action proposals that were stated in the interviews. Its main advantage is that it simplifies the factor descriptions and allows for a quick analysis of the critical nature of a domain;

– a summary document for the set of all domains.

An example of a critical knowledge map is provided in Figure 8.5. The knowledge domains are colored red, orange and green based on their criticality.

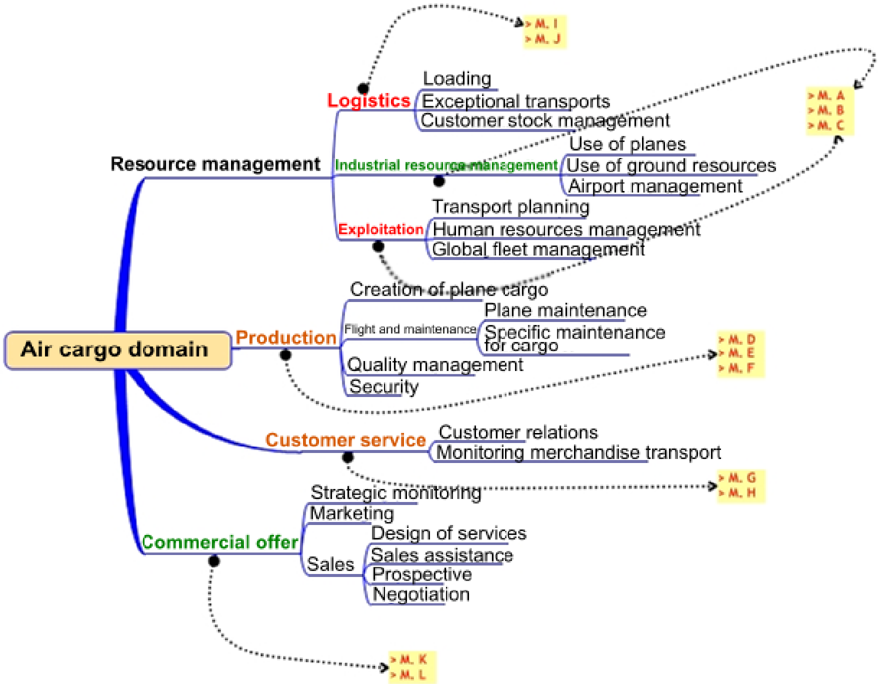


Figure 8.5. *Map of critical knowledge (with referents) for an air cargo company. For a color version of this figure, see www.iste.co.uk/ermine/knowledge.zip*

8.3.3. *Step 3: strategic alignment*

The objective of this step is to compare the strategic perspectives elaborated in the first step (capacities required to reach the objectives) and the professional perspectives of the environment elaborated in the second step (knowledge necessary for the professions in their activities).

This step also makes it possible to formulate relevant recommendations about the KM actions/plans to implement. These recommendations result from the capacities analysis (characterized by the strategic capacities map and their criticality) crossed with the knowledge analysis (characterized by the knowledge domain map and their criticality). This vision at the intersection of strategy and professions is called the strategic alignment. It notably makes it possible to identify “strategic dissonances”: cognitive biases that professional actors have in the representation of strategic objectives and in the representation that strategic actors have of the impact of fixed objectives on professions. Moreover, the considerable material gathered during the interviews with strategic actors and professional actors can be synthesized in light of this strategic alignment to make recommendations for the knowledge capital management action plan.

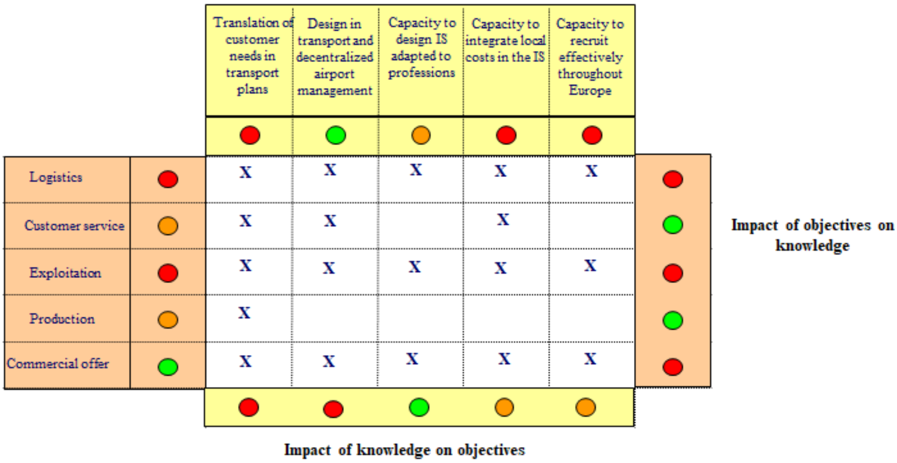


Figure 8.6. *Alignment of capacities and knowledge for an air cargo company*

This step starts by elaborating an influence matrix and weighting the criticalities by alignment. To identify the potential influence of the strategic vision on the professional vision and vice versa, we create a two-way table, an "influence matrix", in which the influences between the knowledge domains and the capacities are indicated. Because each domain and each capacity have a criticality score, a simple weighted mean can be attributed to each element. This score is characteristic of the strategic importance and the criticality of the element. The more critical a strategic capacity is, the more it impacts the knowledge domains, and the more critical these domains are, the greater is its importance. Similarly, the more critical a knowledge domain is, the more it is concerned with the strategic capacities, and the more critical these strategic capacities are, the greater is its importance.

Finally, we can classify knowledge domains and strategic capacities in increasing order of importance.

To illustrate this step simply, consider the example of the air cargo company. The objectives of this company are represented in Figure 8.3 and the corresponding required capacities, with their criticality, are shown in Figure 8.4. The knowledge domains of this company, with their criticality, are provided in Figure 8.5.

The capacity "Designing transport plans and decentralized airport management" was evaluated as "not very critical", but the analysis shows that this capacity involves most of the professional areas (except "Production") in the company, as depicted in Figure 8.6. The alignment therefore requalifies it as "very critical". Similarly, the knowledge domain "Commercial offer" was evaluated as not very critical. However, the analysis shows that all of the capacities required to achieve the company's objectives call upon this knowledge domain. Therefore, the alignment requalifies it as "very critical".

8.3.4. *Step 4: elaborating a KM plan*

The arguments gathered throughout the analyses regarding knowledge and capacities are a great resource and most of the time, they include many suggestions and recommendations. The lines of reflection concerning the KM actions to implement are defined for each knowledge domain and each capacity.

These paths are argued:

– for the knowledge domains, on the basis of summary files elaborated during the analysis of critical knowledge and the main points identified (these consist of recurring elements highlighted during interviews that characterize the criticality of the domain such as need for a knowledge sharing tool, poorly adapted training plan, absence of knowledge capitalization plan, strong technicality of the knowledge domain, etc.);

– for the capacities, on the basis of arguments gathered during interviews with the strategic actors;

– the criticality of knowledge domains, as we saw, must be weighted by the alignment by considering how each domain is influenced by the objectives set by the company (the criticality of a domain increases with the number of objectives that it is involved with);

– a document to aid decision making must be created that summarizes all of the information that was collected during the previous phases. For each domain, this document includes:

- the criticality score obtained during the evaluation phase;

- the weighting obtained by the alignment with the operational objectives of the company;

- the main facts that justify the domain's criticality;

- the propositions made to reduce the criticality and/or allow for a better strategic alignment.

The action plan can then be created from this document.

First, one or more meetings with the actors (CKO, middle management, key people who created the decision-making aid document, KM experts, etc.) are necessary to analyze the contribution provided and to select the KM actions that the organization would like to include in its KM plan. Normally, this decision is not made solely based on the document provided, but requires KM expertise that can be provided by internal or external KM experts to explain the advantages and disadvantages of different potential actions. There is a wide range of possible actions that can be found in classic KM literature. The choice is not always simple and sometimes even the possibilities are not always identified by the actors.

Second, an official decision-making seminar gathers together all of the people involved in the KM project. The objective is to discuss, modify the action proposals and decide on a consensual KM plan that will be presented to the Board of Directors. The KM plan must then be approved by the Board of Directors.

To provide better visibility, the different areas of the KM plan can be grouped into themes:

– organization, when it concerns managerial actions;

– training, when the actions concern the learning plans;

– capitalization/transfer, when it concerns acts of preserving, collecting, sharing, documenting, etc.

Some examples are provided in the following.

Within each topic, the KM actions are prioritized based on the knowledge domain's rank of importance (or strategic capacity depending on the case) that highlighted it.

Elements of a KM action plan (examples)

– Knowledge acquisition:
- HR process:
- Recruitment
- Professional background
- Expertise background
- Learning process
- Training
- Mentoring
- Corporate university

...

– Knowledge search
- Search for knowledge and information
- Technical and scientific scanning

...

– Knowledge creation
- Creative process
- Research and development process
- Innovation process
- Prospective

...

– Knowledge sharing
- Collaborative work
- Work groups
- Communities of Pratice
- Knowledge communities
- Sharing tools

...

– Knowledge codification
- Codifying tacit knowledge
- Experience feedback
- Writing knowledge documents

...

– Knowledge framework structuring
- Structuring databases and documents
- Designing knowledge servers
- Implementing search engines
- Defining knowledge framework

...

8.4. Conclusion

Designing an action plan for a company's KM project is a complex process that must be conducted with care to ensure the future success of the project.

In accordance with the knowledge-based approach, this action plan results from a complete analysis of a company's knowledge capital. This analysis occurs along two lines: the capacities that are required to reach the company's operational objectives and the knowledge that is necessary for the company's operational activities. This analysis reveals the criticalities on each side regarding capacities and knowledge, which must be aligned. Over the course of the criticality evaluation process, this analysis also reveals many prominent facts and proposals that are essential information that will make it possible to construct an action plan that corresponds to the KM project.

The KM plan is discussed by the actors concerned and validated by the top management in a corresponding way. It is a coordinated and strategic plan that revolves around multiple dimensions: knowledge acquisition, knowledge search, knowledge creation, knowledge sharing, knowledge codification, knowledge framework structuring, etc.

A complete and formalized knowledge capital analysis was described in this chapter. Based on the needs, size and means of the company, it can be adapted, reduced or partial. However, it is important to have a good understanding of the company's knowledge capital and to evaluate the critical knowledge to be managed in order to ensure the company's sustainability and competitiveness.

9

Implementing the KM Plan

9.1. Introduction

The implementation of the knowledge management (KM) plan elaborated in Chapter 8 is a lengthy process that can only be contemplated on at least a medium-term timeline.

As we have often mentioned in this book, implementing a KM plan is equivalent to implementing a KM process framework, such as the one described in section 6.3 where we identified eight major types of processes. This framework must be articulated with the other company processes, sometimes be integrated into existing processes (writing documents, information retrieval, etc.), and optimize actions already in place (knowledge sharing, knowledge transfer, innovation, etc.). This implementation also requires the implimentation of new processes that can be innovative (knowledge maps, knowledge books, knowledge communities, etc.).

In the current state of knowledge about KM, it is not possible to create a satisfactory description of all the possible processes with the corresponding actions and tasks. All the more so because we can (wrongly) attribute a large number of existing processes in a company to KM (for example the processes of information management or documentation) and create more confusion than consensus about the KM project. It is better to focus on processes that are relatively new, consensual and useful, designed and validated during the creation of the KM plan, which fall under the responsibility of the CKO and the company's KM body.

Knowledge Management: The Creative Loop, First Edition. Jean-Louis Ermine.

This chapter describes some elements of a few KM processes. It can provide indications and work tracks that are not available in a standardized way. It respects the approach adopted in this book and the framework proposed in Chapter 6.

9.2. Knowledge organization

– P1: Evaluating and managing the knowledge capital

- P1.2: Managing the knowledge capital (relevance and content quality)

– P2: Maintaining the knowledge capital and ensuring its application

- P2.1: Formalizing and making knowledge available

- P2.2: Ensuring knowledge application

Generally, it is useful to conduct an audit of the knowledge resources that are available in the company. The analysis, which is "knowledge oriented" (What knowledge resources are necessary for the company's activities? Which ones are already available?), almost always reveals dispersed, missing or redundant sources, with the result that the knowledge repository existing in the company appears poorly structured, difficult to access and is far from fulfilling the role that we would like to see it fulfill. This can be explained by the variety of approaches that have been implemented up to this point: approaches for operational information systems, databases, documentary systems, human resources, etc. These approaches were made by different units for specific needs, often without cooperation or coherence, throughout the entire life of the company. Of course, it is not a question of changing everything and designing a new system architecture that would restructure all of these disparate systems. However, with minimal reorganization efforts, a primary analysis may make it possible to optimize certain sources, improve access to different sources, complete missing sources, etc. Given the amount and variety of knowledge sources in a company, this reflection is always useful.

9.2.1. *Tangible resources (explicit knowledge)*

There are two types of tangible material resources:

– Knowledge resources produced by KM processes that formalize knowledge in guides, doctrines, experience feedback, learning modules, R&D products, external resources, etc. We will call this type of resource "technical knowledge", which is available and used outside of current operations.

– Knowledge resources used for operational objectives. These resources, produced by the "business processes", are related to data and information collected in different areas of the company. For example, this includes operations reports, incident reports, data collected during activities, etc. We will call this type of resource "operational knowledge".

9.2.2. *Intangible resources (tacit knowledge)*

Technical and operational knowledge are possessed, applied, shared and transformed by people in the organization. Although this knowledge is not formalized by processes, procedures, guides, etc., it nevertheless forms valuable knowledge capital, which is an intangible knowledge capital that we will call "tacit knowledge".

This intangible capital lives and is shared in different types of knowledge networks: communities, social networks, etc. These networks are often the "living link" between operational knowledge (knowledge as a resource for operational processes) and technical knowledge (knowledge as a resource for support processes, such as research and development, quality, marketing, etc.).

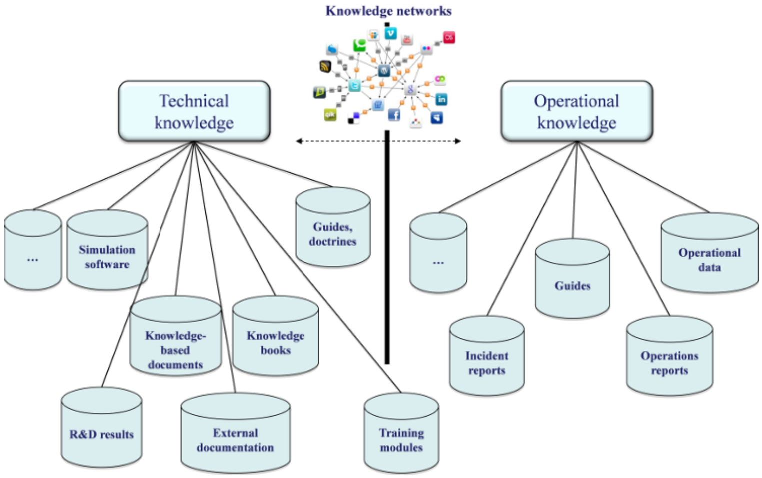


Figure 9.1. *A general architecture for a knowledge repository (example)*

The knowledge repository is the central location where a company gathers the knowledge resources of its processes. This repository can have several components, distributed throughout the company, but it requires a comprehensive vision to avoid redundancies and information conflicts, organize synergies and links between resources, etc.

Figure 9.1 shows an example of the architecture of a knowledge repository making the distinction between "technical knowledge" and "operational knowledge", structured into two modules. Normally, these two modules share some elements, but they can have distinct management. Operational knowledge is managed by operational services, and technical knowledge is managed by KM, R&D, documentation services, etc.

9.2.3. *New knowledge resource additions*

The KM action plan generally reveals knowledge gaps that are not available in the current knowledge repository. Then, it is necessary to add the resources required by knowledge actors. Below, we provide a few typical examples of what KM may require to fill in these gaps.

– Yellow pages

"Who knows what?" This is a directory where experts and specialists are identified with their knowledge domain and the questions to which they can respond. Populating the yellow pages with knowledge actors is a long process, from identifying and validating experts to requiring their mobilization for the benefit of everyone.

– Web resources

This includes URLs (internal and external) that are useful and relevant for knowledge problems. The inventory and centralization of these different addresses can be a difficult and lengthy process.

– Document classification scheme

Accessing documentation is never easy, and a lot of time is dedicated to searching for information. A good classification system facilitates access to documentation.

– Technical and scientific documentation

Especially in complex technical domains, the number of technical and scientific documents is huge. Identifying documentation necessary for different ends and organizing its production and access is necessary.

– Training resources

Training modules are a specific and shared way to access certain pieces of knowledge in an organization. The links in the knowledge repository can highlight some training system modules.

– Access to knowledge communities

Identifying and organizing access to varied and numerous knowledge communities (working groups, communities of practice, communities of interest, etc.) are important to disseminate knowledge within the company.

9.3. Knowledge codification

– P2: Maintaining the knowledge capital and ensuring its application

- P2.1: Formalizing and making knowledge available
  - Eliciting tacit expert knowledge
  - Formalizing operational knowledge
- P2.2: Ensuring knowledge application

The activity of codification is one of the most common activities in an organization. Whether it consists of writing reports, notes, documents, populating databases, developing procedures, etc., the activity of producing structured information is constant in all activities in a company. In this context, knowledge codification is difficult to identify as such. It is a subject in its own right and a brief introduction is available for consultation in element no. 7 of the BourbaKeM treaty [THO 14]. To simplify, we can say that codification is a process that transforms tacit knowledge into explicit knowledge using socially shared codes and symbols. These codes can be written texts, images, maps or any symbolic form used as a language. Knowledge established on paper or digital formats is therefore explicit knowledge that is, theoretically, transmissible once the system of codes and symbols is known and shared.

The codification process is not neutral because the explicit knowledge that it creates is “one” representation of the world that depends on the language adopted and understood by one community. It will also influence both the way to see the phenomenon studied and the way of representing it. It produces new knowledge that is not a substitute for the tacit knowledge in which it is rooted, but it is complementary to it. It has many positive aspects such as better understanding of the phenomenon concerned and developing new proposals, thereby facilitating communication, coordination and cooperation between members of the organization. Of course, the codification process has a cost related to the time, resources and managerial attention necessary to codify the knowledge.

Here, we will study some classic KM knowledge codification processes that may be original compared to what is already known in this domain.

9.3.1. *Lessons learned*

The Project Management Institute (PMI) defines lessons learned as the learning gained from the process of executing a task. Lessons learned can be identified and codified at any time during the life cycle of a project. The purpose of documenting lessons learned is to share and use knowledge derived from experience to:

– promote the recurrence of desirable results;

– prevent the recurrence of undesirable results.

In practice, lessons learned include the processes necessary for the identification, codification, validation and dissemination of the applicable experience to the appropriate personnel and a follow-up to ensure that the appropriate actions have indeed been taken.

Implementing an effective lessons-learned process is one of the most popular KM processes. For every critical task, or every important project, it is very useful to put such a process in place. This process is an international standard in project management and many guides are available for its implementation. For instance, we can consult the PMI Website (2017):

https://www2a.cdc.gov/cdcup/library/pmg/implementation/ll_description.htm.

9.3.2. *Knowledge-based documents*

9.3.2.1. *Introduction*

Knowledge-based documents or knowledge codification documents are a generic name to designate any type of documents of general scope that requires the elicitation of tacit knowledge involving the participation of one or more experts in a domain, specialists in a task or activity, etc. For instance, this includes rules, principles and doctrines, as well as user manuals, maintenance guides, white papers, training materials, etc. The lessons learned as described in section 9.3.1 produce a knowledge-based document (knowledge resulting from experience). These documents are essentially intended to share knowledge.

Codifying tacit knowledge in document form is an editorial problem. However, this drafting phase is often tricky to implement, as the difficulties outlining a field or adapting it to potential readers is often an obstacle to sharing knowledge. An editorial process is necessary, intended to foster the expression of knowledge involved in the drafting process. We have described one, inherited from works that the French KM Club was commissioned, “Writing to share knowledge” (which was directed by Jean-Luc Richard), an approach that should be customized based on expectations, project specifications and environment.

At the center of the editorial process is the knowledge manager or knowledge engineer who is the “editor-in-chief”, the guarantor of coherence from the definition of objectives to the final formatting and the uniqueness of the editorial style. Several contributors are generally called upon to intervene on this type of project, and the document can only be coherent if it is consolidated by a single person. This person must set specific objectives for the project and the expected benefits. This work requires research, interviews and the management of different contributors, which requires a solid project management approach.

9.3.2.2. *The editorial process*

The editorial process proposed is illustrated in Figure 9.2. It is guided by the document content. Different expertise and concepts are distributed in each phase of the process, which are foundational for the success of the project. Each one of them will be developed through questionnaires, which should be customized according to the situation and implemented prior to each step in order to obtain the clearest vision possible of the work to be done.

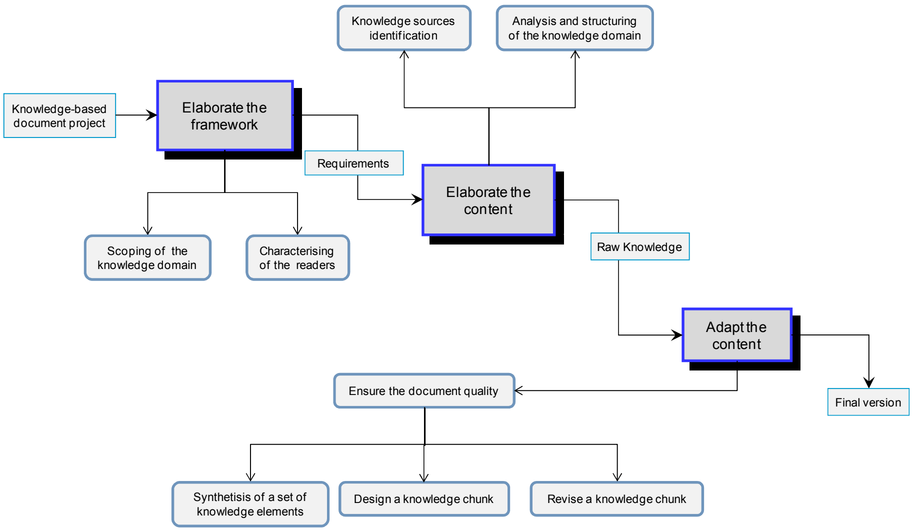


Figure 9.2. *Editorial process for a knowledge-based document*

– The framing step is the first step to implement: outlining the knowledge domain and characterizing the readers will determine the actions to take during the following steps.

– The content collection step involves exhaustively identifying knowledge sources and structuring the knowledge domain. These two skills make it possible to gather information as close as possible to the needs.

– Finally, adapting the content is completed by considering the characterization of the readership already carried out and responds to different writing quality criteria.

9.3.2.3. *Framing the content*

The first task to carry out is to outline the knowledge domain. This consists of drawing the boundaries of the knowledge domain that is the subject of the written document to find a balance between the accuracy of the document's content, its objectives and the time required to write it. In effect, if the subject is addressed from too general of an angle, the editorial effort will be enormous. Inversely, if the perspective is too restricted, the writing risks resulting in a document that will not be very useful.

In order to avoid these obstacles, finding the right title to describe the document is a big help. In most cases, the knowledge domain studied is directly related to a process, but not always. In order to define the field of the project, it is this domain (potentially this process) that it is important to identify in its entirety as well as in the set of resources implemented, whether they are human, material or methodological.

Useful questions to outline the knowledge domain

– Is the title of the document:

- Simple: at best, a verb and a complement?

- Relevant: does it correspond to the objectives set out in the document?

- Meaningful: does it make it possible to identify the specialists, experts, etc. that will need to be questioned?

– The knowledge domain:

- *The process:*

- Is there one or several processes related to the knowledge domain?

- What elements are necessary to input for its implementation and realization?

- What results are produced by this process?

- What are the devices, procedures, software, etc. necessary to complete the process?

- *Actors:*

- Who are the people and the groups of people involved in the domain?

- What is the degree of involvement for each person and group (from a subordinate to a decision maker)?

- *Information flow:*

- What information is used, produced, and stored in this domain?

- In what form and through what channels does it circulate?

- *Environment:*

- In what context is the project document developed?

- Are these contextual elements likely to have an impact on the use that can be made of the document?

The second task to carry out to provide a framework for the document is to identify the readership. Generally, the document is addressed to a homogeneous population about which certain characteristics should be known. This consists of identifying the potential readership to produce a document that is adapted to it in form and content.

Useful questions to identify potential readers

– What are the general characteristics of the readership?

- Personal culture
- Level of education
- Knowledge of ICTs (Information and Communication Technologies)
- Language(s) known

– What are the specific characteristics of the readership?

- Profession
- Hierarchical position
- Job characteristics

– What is the context and circumstance of the reading?

- Habits regarding information retrieval and use
- Availability

– What is the level of expertise of your readership regarding the specific practices in the knowledge domain?

- Novice, without any knowledge of the practice.
- Specialist, able to solve a problem but not provide an in-depth explanation.
- Expert, able to solve a problem and explain it.

9.3.2.4. *Collecting content*

The first task to carry out is to identify knowledge sources. There are many types of knowledge sources:

– resource people and networks;

– knowledge resulting from professional meetings;

– practices in effect in the domain;

– documentary and information resources.

This step consists of identifying all of the knowledge sources to be sure that nothing is forgotten.

Useful questions to identify knowledge sources

– Resource people and networks:

- Who are the people with an interesting, recognized experience in this knowledge domain?

- What is the specific area of expertise of each person, and what could be their potential contribution to writing the document?

- Who are the people that could be indicated to readers as references or useful contacts?

- Are there any professional associations, communities of practice or work groups involved with the knowledge domain? Which ones?

– Professional meetings:

- What are the meetings, seminars, expositions, workshops, trade fairs and other conferences during the last 3 years in this knowledge domain?

– Practices in effect in the domain:

- What are currently the most commonly used technological tools in the practice context?

- Are there methodological tools (procedures, quality standards, best practice rules, etc.) used in the practice context?

– Documentary resources:

- What are the relevant specialized libraries, key periodicals and books, Internet sites and discussion groups?

- What is the documentation for your domain?

The second task to carry out is the most important of all, the longest, and definitely the most complex: analyzing and structuring the knowledge domain. This consists of structuring different types of knowledge in order to adopt appropriate collection methods to gather and codify knowledge from the right people ("knowers" or "knowledge holders").

What we call "knowledge types" can vary depending on the situation and each case can create its own knowledge categories. Similarly, there are countless collection and codification techniques, ranging from simply writing down interviews to very structured methods. These methods can use very diverse codification languages, from natural written languages to programming languages, including diagrammatic or graphic representations.

For example, the "Knowledge book" method presented in section 9.3.3 proposes a generic method for all knowledge domains with six types of knowledge and a codification method that uses graphic language for each type. These types are as follows:

– domain activities (or process);

– domain know-how;

– domain phenomena;

– domain history;

– domain concepts;

– domain evolution.

Consider the example presented in the below table.

Useful questions for analyzing and structuring a knowledge domain
– Can we identify the knowledge to collect on the subject based on the typology below? (It is not always necessary to use all six types.) - Activities or process - Know-how - Professional phenomena - History - Concepts - Evolution

– Does one (or more) type(s) of knowledge clearly appear to be a priority? Why?

– What type(s) of knowledge do not appear to be important for the project framework? Why?

– Can we classify the knowledge sources according to this same typology?

– Based on the knowledge types identified, it is important to prepare for the collection of knowledge from resource-people:

- Do we have general techniques for conducting the knowledge collection interviews?

- Do we have analysis grids or questionnaires corresponding to each type of knowledge identified to collect, in order to adapt the interviews?

9.3.2.5. *Adapting the content*

The knowledge collected must now be formatted to create the final document.

This is done by synthesizing a set of knowledge elements. It is necessary to sort, classify and group the collected material. The knowledge must be grouped in the form of different knowledge elements, related to one another by a major theme. The challenge is to prioritize and consolidate the knowledge collected in order to organize it and thereby give it meaning.

Useful questions to synthesize a set of knowledge elements

– Can we establish knowledge elements?

- Are there elements that are out of context, to be removed?

- What knowledge appears to be a priority?

- Can we classify the set of knowledge collected around the knowledge identified as priorities?

– For each knowledge element:

- What is the main idea? Does this idea inspire a meaningful title?

- Based on this main idea, is the specific content attributed to this element relevant and homogeneous?

- Is the element really relevant for this knowledge domain? Can we justify its existence?

- Does it reveal unaddressed questions or gaps in the knowledge collection?

– Is the set of knowledge elements coherent and did we verify that there are no redundancies?

– Is there a dominant theme that can connect these elements to one another?

- Out of all these elements, is there one that best structures the knowledge in the document?

- What structuring of the elements around this topic seems the most evocative or the most relevant for readers?

Next, we must know how to compose a knowledge element. By composing knowledge elements, we define which modalities we want to present the knowledge elements in: text, visuals, multimedia. It is important to choose the form that will be able to allow the best identification and comprehension of these elements. The challenge is to draft each knowledge element in the most appropriate way and in great detail. The editor will then proofread in the next step: revision.

Useful questions to compose a knowledge element

– Is the element clearly identified?

- Is the title clearly identifiable?

- Can we easily understand the meaning and value?

- Can we situate it in relation to the other elements?

– How is the explanation of the element developed?

- Are there illustrations for the examples and specific cases in line with the readers' experience?

- When a concept is abstract, do we try to translate it with a metaphor or a comparison that makes sense for the readers?

- Do we use proverbs, aphorisms, or other strong formulas that capture the imagination and facilitate memorization?

- Do we address readers directly? (by appealing to them, calling them as witnesses, etc.)

– What material should mainly be used to support this explanation?

- Words?

- Multimedia?

- Visuals? (Isn't an image worth a thousand words?)

– The links: can we cite:

- people (experts, etc.) that the readership can contact to obtain additional information?
- documentary resources that will provide supplements for the information given?

Next, take time to revise the knowledge element. Attentive revision is important to verify that each element responds to the quality criteria of a text in order to ensure coherence and readability.

Useful questions for revising a knowledge element

– Did we remove unnecessary information that is likely to generate noise?
– Is the organization of the subelements coherent?

- Does each subelement develop only one idea?
- Are the logical links between each subelement explicit?
- Do the connections between subelements appear clear? For instance, do we use:
    - Subheadings?
    - Graphic links?

– Does the writing allow for an incorrect or erroneous interpretation by the reader?

– Is the presentation balanced? What is ratio of figures to text?

– Could the syntax be improved? Here are a few points to consider:

- Sentence length.
- Simplicity of wording and appropriate vocabulary for the readers.
- Language errors.
- Typing errors.

– Is the formatting attractive?

– Do the illustrations really add value to the information presented?

The last step involves verifying the quality of the document by considering the readership. The document quality must guide every step of the content adaptation in order to produce a document that is appropriate for its audience, studied in step 1. Producing a quality text comes down to connecting its content, form and audience.

Useful questions to verify document quality

– Are the materials suitable for readers?

- Do the terminology and vocabulary correspond to reader norms?

- Is the same thing true for the illustrations (visuals, multimedia animations, etc.)?

- Are the rules of syntax respected?

– Does the organization of the elements facilitate reading?

- Do the sets established (lists, etc.) contain a maximum of seven items?

- Has the attractiveness of the formatting (fonts, spacing, margins, paragraph length and lists, etc.) been verified?

- Is the formatting consistent?

– Does the presentation enhance the content?

- Is the essential information highlighted by the formatting?

- Is the structure of the document clearly identifiable?

- Do the connections between the different elements appear clear?

– Is the content organized logically?

- At the level of the whole document, is there a logical theme around which the elements are all structured?

- Within each knowledge element, are the ideas organized logically?

– Is the text comprehensible by readers?

- Context: does the reader have enough information about the context to understand the document?

- Knowledge: does the reader have a sufficient level of knowledge to understand the document?

– Is the text clear? Is it easy to read?

- Does the time required to read and understand the document correspond to the availability of readers?

- Will the readers learn something new from reading this document?

9.3.2.6. *Conclusion for knowledge-based documents*

A knowledge-based document is distinguished from other documents in a company by the fact that to draft it, it requires the intervention of people who possess remarkable knowledge about the given domain. Due to this, drafting such a document cannot be limited to a simple technical writing framework (a “Technical Definition of the Document”) and must be the subject of particular attention and a specific process.

Through the mobilization of knowledge holders and the comprehension of actors receiving knowledge, a company can codify a certain part of its knowledge capital to make it less vulnerable, more accessible and more capable of evolving.

9.3.3. *Knowledge books*

9.3.3.1. *Introduction*

The knowledge in an organization is primarily tacit, embedded in the brains of actors, especially experts. The ratio between tacit and explicit knowledge in organizations is often evaluated as 80%:20%. Knowledge that is both critical for the organization and tacit in the brains of collaborators is an important risk factor for a company (knowledge loss). It is therefore important to implement ways to preserve and transfer the knowledge of collaborators that are both critical and have a strong tacit component.

Knowledge books are a generic term to designate knowledge-based documents dedicated to the preservation and transfer of tacit knowledge. More generally, they can consist of electronic artifacts such as websites (knowledge servers or knowledge portals) or hypermedia documents in all forms (such as PowerPoint).

A knowledge book is the result of the codification of tacit knowledge by experts or specialists (more generally, this includes “knowers” or “knowledge holders”) who formalize their knowledge and relate it to various information sources (documents, databases, images, films, etc.) in order to transmit it to a specific community.

The technique of creating the knowledge book that we describe here is a knowledge engineering technique based on knowledge models obtained because of the intervention of a “knowledge engineer” or “cognitician” who conducts interviews with the knowers concerned and models their knowledge using predefined graphic diagrams. This technique is currently being developed, particularly in France and the United States, and it is one of the components of the MASK method (Method for Analyzing and Structuring Knowledge). This is a tool available to the French KM Club. For a brief introduction to knowledge engineering, we can consult element no. 12 in the BourbaKeM treaty [MAT 17].

Constructing knowledge models from expert interviews is not easy. During the interviews, the experts essentially provide:

– informal information while speaking, explaining things, etc.;

– more formal information through documentation, texts, images, films, etc.

To elicit knowledge from this information, we rely on the theory that states that knowledge is formed by information that acquires meaning from a given context. This consists of:

– describing a context of interpretation for the information given;

– giving meaning to the information provided.

The knowledge book technique presented here is based on the theory presented in the first part of this book. According to this theory, describing the context in a given domain requires the description of three types of knowledge:

– the basic phenomena in the domain;

– the organization of activities in the domain;

– the history of the domain.

Moreover, giving meaning to information collected requires the description of three other types of knowledge:

– domain concepts;

– domain know-how;

– domain evolutions.

The knowledge book technique provides ways to elicit these six types of knowledge from interviews. To facilitate this task, instead of describing these types in text, the method proposes six graphic representations called "knowledge models" that are described in detail below. This is in line with the old adage that "a picture is worth a thousand words".

9.3.3.2. *The process of creating a knowledge book*

Developing a knowledge book requires several steps.

9.3.3.2.1. Step 1: scoping

The purpose of the scoping phase is to outline the knowledge domain that the knowledge book will focus on and establish a preliminary table of contents that will indicate what modeling to conduct. This makes it possible to validate the feasibility of the project and put in place a work plan.

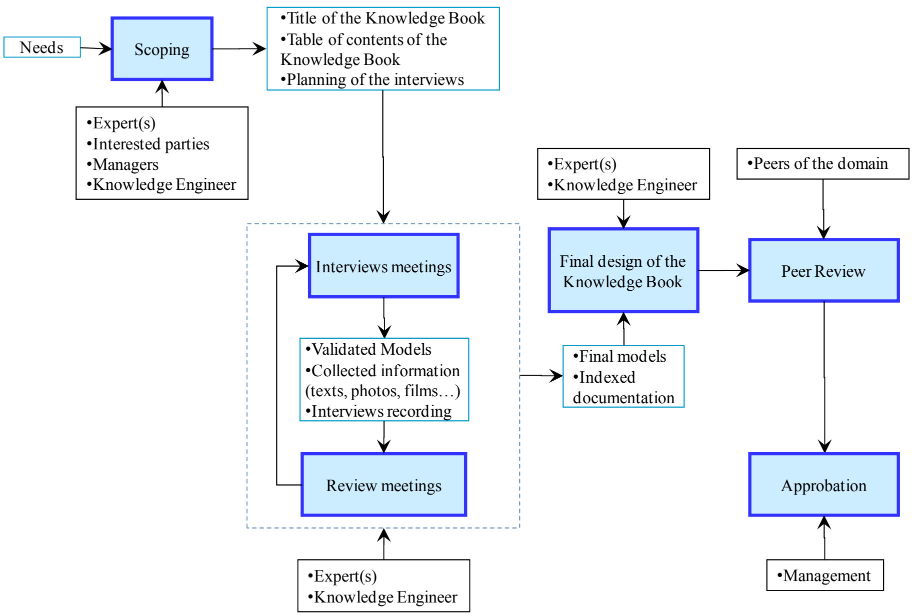


Figure 9.3. *Process of creating a knowledge book*

9.3.3.2.2. Step 2: creating the knowledge book

Creating a knowledge book is a complex process that requires several tasks:

– Co-constructing knowledge models with experts:

Expert interviews provide a set of models with documents, information and possible references. By grouping certain knowledge models and various elements, we construct different chapters of the knowledge book.

– Build a consensus between the contributors to the book.

– Design and produce the knowledge book:

Designing the architecture of the book and finalizing its presentation is an important job.

– Validate the content of the knowledge book:

The knowledge capitalized in the book must be validated by a committee composed of peers recognized by the company.

– Approve the knowledge book:

Finally, the knowledge book must be approved by the hierarchy. This is important to ensure that the knowledge capitalized is indeed recognized as company knowledge and that it must be used as such.

9.3.3.2.3. Step 3: sharing the knowledge book

The sharing phase is essential for the success of the knowledge transfer operation intended by the creation of the book. It guarantees that the knowledge is available to everyone who needs it, so that they can use it in their professional practices and so that it can continue to evolve.

9.3.3.2.4. Step 4: evolution of a knowledge book

Knowledge is always evolving. It is necessary to implement a process to supervise the evolution of the knowledge book. This is a specific process that cannot be reduced to a simple operation of classic maintenance. It requires several tasks:

– identifying new emerging knowledge;

– submitting and validating new knowledge to integrate into the knowledge book;

– modifying the knowledge book and validating its evolution.

9.3.3.3. *Codifying different knowledge types*

In this section, we provide a definition and description of six basic knowledge types used to codify tacit knowledge. A formal description and a graphic syntax are also provided.

9.3.3.3.1. Type of knowledge: phenomena

Overview

Definition	*A phenomenon is:* – an effect; – an event; – etc. that we seek to control, understand, trigger, optimize, inhibit or decrease in the professional activity concerned.
A phenomenon describes	*A phenomenon can describe:* – physical–chemical effects to be controlled in an engineering activity; – psychosocial influences between individuals and social groups; – dangers or risks (fire, explosion, financial risk, social risk, etc.) related to systems involved in the activity; – etc.
Utilization	*Describe the knowledge as a phenomenon if:* – engineering problems: physical effects in general, phenomena that appear in process controls; – change management (interaction phenomena between actors, etc.); – risk analysis (natural risks, technological risks, etc.).
Use case	*Use the “phenomenon” type of knowledge when:* – you must explain the basic principles of the domain; – you want to specify, in your specific context, things that are generally known (in the scientific domain, for example, in the classic university training of the domain).

Description of a phenomenon

The description must include the following elements:

– The initiating (or triggering) event.

– What are the initiating events of the phenomenon?

– The source of the phenomenon:

What phenomena appear as the source of the phenomenon and where do they appear?

– The flow:

What are the flows created by the source phenomenon (energy, material, information, etc.)?

– The target of the phenomenon:

What are the phenomena observed on the target, what are the flow effects created and where do we observe these effects?

– The consequence:

What are the consequences of the phenomenon?

– The influence parameters:

What are the parameters that influence the global phenomenon, and which are external to the phenomenon?

NOTE.–

– It is recommended to elicit the properties or parameters of the elements positioned in each component of the phenomenon (source phenomena and target phenomena, flow created).

– It is recommended to add links to associated information, images, films, etc. to the model.

– Example: Triboelectric effect.

The example in Figure 9.4 is from a project that was completed by the *Office National d'Études et Recherches Aérospatiales* (ONERA) by Alain Thiriot and Philippe Benhamou about the design and realization of non-intrusive sensors.

The design and realization of sensors requires a complete understanding of a certain number of physical–chemical effects that are well known in engineering. The example of the triboelectric effect is provided below. For this type of knowledge, we provide a (simplified) verbal description given by an expert who was questioned.

> When we install a (non-intrusive) sensor on a profile, whether it is in a wind tunnel or in real conditions, the movement of the fluid (generally the air) creates a friction on the sensor.
>
> The friction creates an electrostatic field on the interior of the dielectric of the sensor. This field is proportional to the friction surface. In a homogeneous dielectric, the effect is more sensitive because the field propagates without discontinuity. Certain dielectrics are constituted of various forms of macromolecules with particular electric dipole moments. Submitted to a given field, the set of these moments on the macromolecules can contradict itself and influence the nature of the triboelectric field created.
>
> The orientation of the field created by the friction is variable. We think that for manufacturing reasons, the two faces of the dielectric (internal face and external face in relation to the coil because the dielectric is delivered in the form of a coiled film) do not have the same properties. The orientation of the field can change depending on the face subject to the friction.
>
> Following the orientation of the field, the parasite ddp is added or subtracted from the signal. The measurement carried out is therefore distorted. This bias disappears with the friction (not the accumulation of charge).
>
> To cancel out this phenomenon, simply ground the electrode subject to the friction. This can be done in two ways: (1) directly on the profile if it is metal; (2) on a metallic surface added to the profile and connected to the ground if the profile is isolating. We must always take the measurement on the electrode not subject to the friction.
>
> The triboelectric effect increases with the temperature.

Figure 9.4 shows a diagram and a graphic syntax to model a phenomenon, notably making it possible to codify expert discourse.

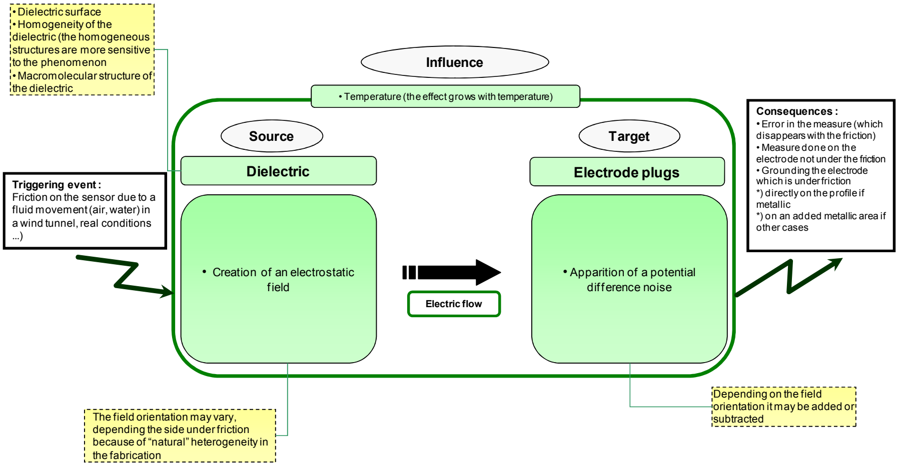


Figure 9.4. *Example of a phenomenon model. For a color version of this figure, see www.iste.co.uk/ermine/knowledge.zip*

9.3.3.3.2. Type of knowledge: activity

Overview

Definition	*An activity is:* – a breakdown into several phases of the professional activity under consideration; – a process (*business process*); – etc. that describes the global function organization in activities with added value in order to reach a given operational objective.
An activity describes the organization in phases that leads to a given production in output.	*An activity can describe:* – a transformation of flow (energy, material, information, etc.) between different phases; – the organization in different sequences or phases of a professional activity; – etc.
Utilization	*Describe the knowledge as an activity if:* – you want to describe the process(es) related to your subject; – you want to describe a "How to" guide; – etc.
Use case	*Use the "activity" type of knowledge when:* – you are in a quality assurance process; – you are writing an operational guide; – you are describing a supervision process; – etc.

Description of an activity

The description can include the following elements:

– Breakdown of the activity:

The activity is broken down into main phases, which are subactivities, that can be broken down as well, and so on.

– Flow:

- Input flow: Input of the activity (energy, material, information, etc.) transformed by the activity.

- Output flow: Output resulting from the transformation of input by the activity.

– Actors:

People or roles involved in the realization of the activity.

– Resources:

Tools (instruments, software, documents, references, etc.) that are necessary for the activity, and that are pertinent to indicate.

– Knowledge, skills, attitudes (KSA):

- *Knowledge*: what basic knowledge is necessary to realize the activity?

- *Skills*: What are the skills to develop to be competent in the realization of the activity?

- *Attitude*: What are the specific attitudes required in the realization of the activity?

NOTE.–

– The linear breakdown of an activity into phases should not include more than four subactivities for reasons of comprehension and reading. If not, a hierarchical breakdown must be used, where the breakdown of a subactivity is described in another part of the model.

– It is recommended to add links to associated information, images, films, etc. to the model.

– Example: Design of an information system.

The example in Figure 9.5 is part of the activity of designing an information system that follows a rather classic process in four phases: preliminary study, detailed study, technical study, realization. This example concerns the "Detailed study" phase.

Figure 9.5 shows a diagram and a graphic syntax to model an activity, notably making it possible to codify expert discourse.

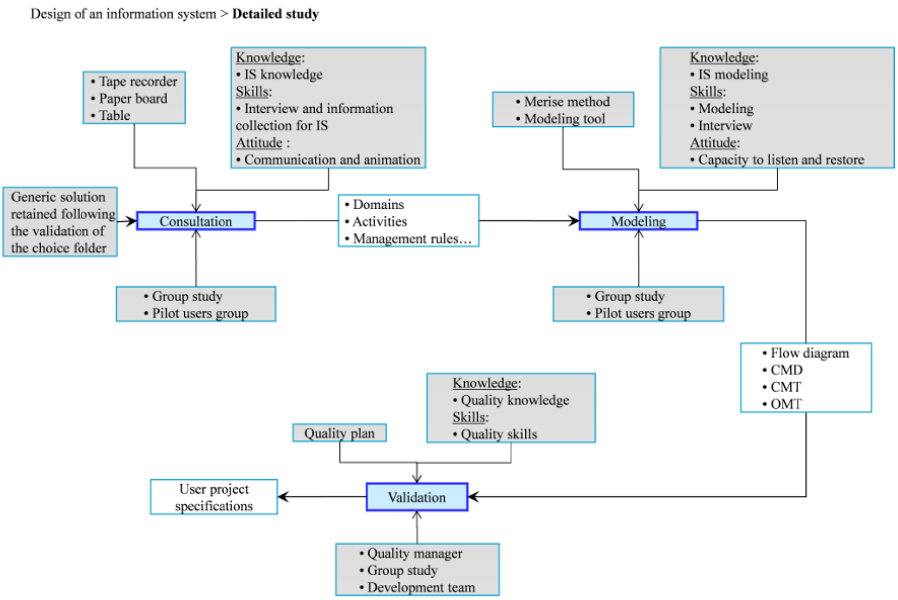


Figure 9.5. *Example of the activity model*

9.3.3.3.3. Type of knowledge: history

Overview

Definition	*A history is:* – a summary of highlights from the history of a knowledge domain, with the dependency relations and characteristic influences of this history; – the integration of the domain into an evolutionary context that explains its evolution, allowing for a global, broad stroke approach that led the knowledge to its currently perceived state.

A history describes the key factors, the generations, the milestones and the influences that are characteristic of the evolution of the knowledge domain.	*A history can describe:* – the development stages of a technology based on the different sociotechnical constraints of the domain; – the history of a domain with the milestones, key events, etc.
Utilization	*Describe the knowledge as a history if:* – you think that the knowledge in the domain cannot be understood without knowing its history; – You want to keep track of the global development of the knowledge domain; – etc.
Use case	*Use the "history" type of knowledge for:* – an introduction to professional training; – transmitting a professional culture; – etc.

Description of a history

– Timelines: Significant elements that determined the evolution of the knowledge.

– Generations: Succession of generations in time, in each timeline.

– Objective(s) that are related to the occurrence of each generation.

– Milestones: Important dates for a generation (events, publications, reference documents, etc.).

– Evolutionary link: An important and significant connection between two generations on the same timeline.

– Influence links: An important and significant connection from one generation on one timeline to another generation on another timeline. More generally, these influence links can connect different elements in the history.

NOTE.–

It is recommended to add links to associated information, images, films, etc. to the model.

– Example: Elements of the history of the safety of cooling pools in the nuclear industry.

The example in Figure 9.6 is taken from a knowledge book created at the IRSN (*Institut de Radioprotection et Sûreté Nucléaire*, or Institute for Radioprotection and Nuclear Safety) about "storing nuclear fuels in cooling pools". It consists of capitalizing on knowledge about potential incidents and accidents in fuel storage devices in French nuclear power stations. In effect, after being used for the production of electricity, nuclear fuel must be replaced and the used fuel is temporarily stored near the stations concerned in what is called a "cooling pool", waiting for its radioactivity to decrease before its definitive storage in a specialized center. These devices, of course, require particular safety analyses to ensure their safety in all conditions, even the most extreme. The safety analysis of such devices has evolved as a function of the advancement of knowledge in this domain, events that have occurred around the world, and even evolutions in the production of electricity in the stations. This is what the history retraces in broad strokes.

Figure 9.6 shows a diagram and a graphic syntax to model a history, notably making it possible to codify expert discourse.

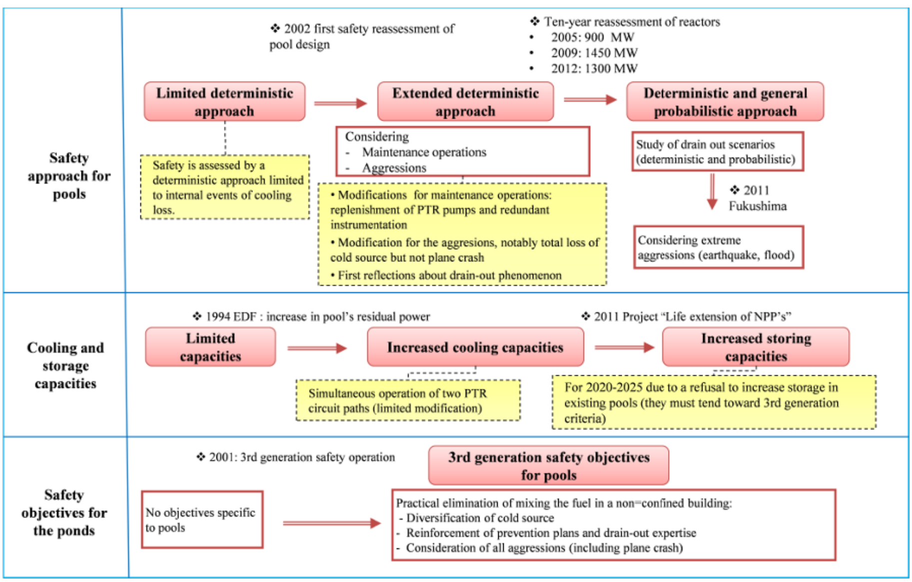


Figure 9.6. *Example of a history model. For a color version of this figure, see www.iste.co.uk/ermine/knowledge.zip*

9.3.3.3.4. Type of knowledge: concept

Overview

Definition	*A concept (or concept network) is:* – an object from the domain, conceptual or real, broken down into other concepts; – a classification of professional concepts or objects; – etc. that describes the conceptual and contextual organization of one or more experts in the domain.
A concept network describes the real or conceptual classification of objects, specific to a professional vision by experts.	*A network of concepts can describe:* – a taxonomy, an ontology of a domain; – the organization into structured objects of elements that are used by a given domain; – etc.
Utilization	*Describe the knowledge as a concept if:* – you want to specify the relations between different elements that you use in your activity; – you want to specify the vocabulary of your activity; – you want to structure your objects or your concepts; – etc.
Use case	*Use the "concept" knowledge type for:* – defining a professional vocabulary; – creating a taxonomy, an ontology; – creating a conceptual model for a database; – discussing a shared vision of a domain; – designing a conceptual map (for a scanning activity, for example); – etc.

Description of a concept

The description can include the following elements:

– The breakdown of a concept into subconcepts:

In a network of concepts, there are two types of links:

– Definition links: The concept is described with a certain number of attributes, which are concepts that are potentially also broken down into other concepts.

– Classification links: The concept is divided into subconcepts that are potentially divided into subconcepts, and so on.

NOTE.–

It is recommended to add links to associated information, images, films, etc. to this model.

– Example: Human factors to consider in a change action, the psychological factors, in particular the "connection strengths".

Figure 9.7 shows an example taken from a knowledge book completed by the consultants Jean-Marie and Éliane Bézard to capitalize on their know-how about conducting change in organizations. The network of concepts classifies, in a sophisticated and descriptive way, all of the human factors to consider when guiding change: psychological, group and sociological factors. Among the psychological factors, for instance, there are "connection strengths" and "disconnection strengths". Among the "connection strengths", there are "primary connection strengths" and "secondary connection strengths", etc.

Figure 9.7 shows a diagram and a graphic syntax to model a concept network, notably making it possible to codify expert discourse.

The "definition"-type links are represented by solid lines and the "classification"-type links are represented by dotted lines. A shaded box indicates a concept that is depicted in another diagram.

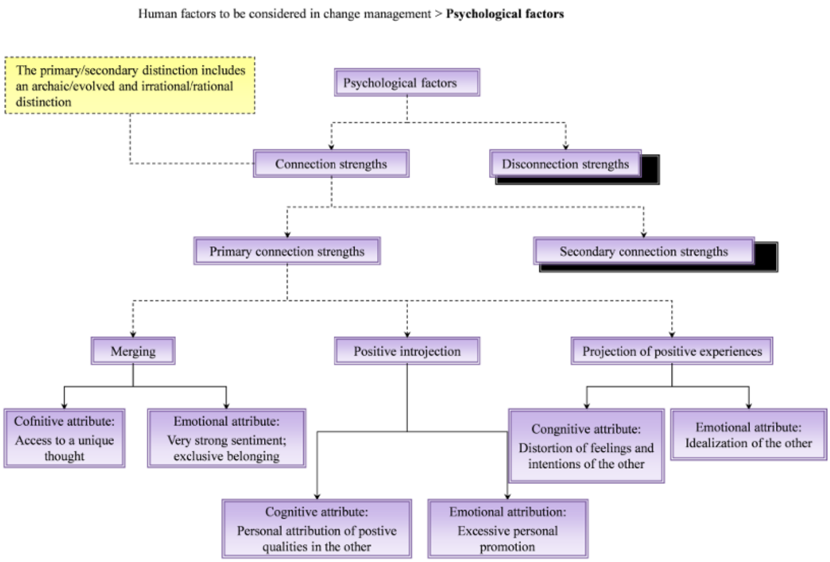


Figure 9.7. *Example of the concept model. For a color version of this figure, see www.iste.co.uk/ermine/knowledge.zip*

9.3.3.3.5. Type of knowledge: task

Overview

Definition	*A task (or skill) is:* – the breakdown of a method of solving problems on a specific topic into a sequence of tasks; – a kind of procedure; – etc. that analytically describes the method used by one or more experts to solve a specific and recurring problem in their activity, for which they have developed a remarkable skill.
A task (skill) describes an arrangement of tasks to solve a given problem.	*A task (skill) can describe:* – a procedure; – a method acquired by experience; – etc.
Utilization	*Describe the knowledge as a task if:* – you have identified a localized but remarkable expertise that is worth eliciting; – it consists of capitalizing and transmitting on “tricks” or “mind tricks”; – etc.

Use case	*Use the "task" knowledge type for:* – an undocumented "manufacturing secret"; – a "knack" that is recognized but not elicited; – a problem-solving strategy to clarify; – etc.

Description of a task

A task is divided into a sequence of other tasks, or it is terminal.

There are different types of tasks:

– sequential task: a broken-down task whose subtasks are activated sequentially;

– alternative task: a broken-down task whose subtasks are activated if the condition connected to them is satisfied;

– repetitive task: a task that is active on a list of objects, or as long as its condition is not satisfied;

– parallel task: a task whose subtasks are activated in parallel.

NOTE.–

It is recommended to add links to associated information, images, films, etc. to the model.

– Example: Adjustment of thickness during cold rolling.

The example in Figure 9.8 presents a task in the domain of cold rolling in the steel industry. It describes a set of adjustments that are made on the rolling process.

Cold rolling mills reduce the thickness to a final thickness requested by the client. They give a shinier finish to bands and sheets and harden the metal. The thickness of the lubricant film between cylinder and metal plays an important role in the rolling. A large part of the skill of the roller resides in the adjustment of pressures, flows, orientation of the watering, the choice of lubricant and conducting lubricant baths to obtain the desired surface aspect and intended thickness.

Figure 9.8 shows a diagram and a graphic syntax to model the task tree, notably making it possible to codify expert discourse.

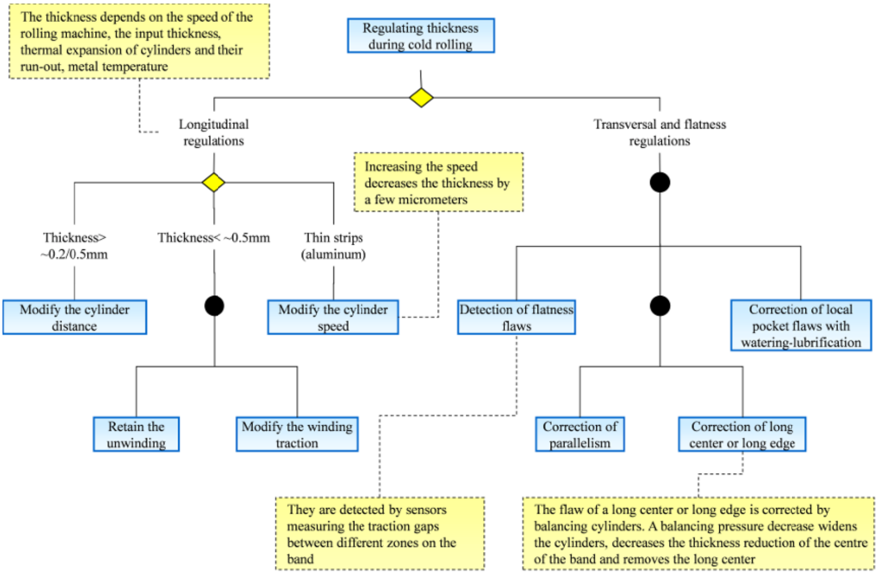


Figure 9.8. *Example of the task model. For a color version of this figure, see www.iste.co.uk/ermine/knowledge.zip*

9.3.3.3.6. Type of knowledge: lineage

Overview

Definition	*A lineage is:* – a temporal sequence of concepts or objects in an evolutionary order, reflecting the successive changes (improvements, modifications, alterations, changes, etc.); – successive generations of objects or concepts; – a genealogical tree that successively traces the appearances and possible disappearances of generations.
A lineage describes the evolution of objects or concepts in a domain with the corresponding arguments	*A lineage can describe:* – the evolution of a given technical object; – the evolution (ideas) that led to a given concept; – etc.

Utilization	*Describe the knowledge as a lineage when:* – you need to refer to solutions already designed in order to design a new solution; – you want to preserve the arguments for the design of a product or service; – etc.
Use case	*Use the "lineage" type of knowledge for:* – retracing decisions in design meetings; – explaining the progress of a project, the development of a concept; – realizing a "Design Rationale" activity (capitalization of design arguments); – etc.

Description of a lineage

A lineage can include the following elements:

A genealogical tree, whose branches are lineages.

– Lineage: Temporal sequence of generations of concepts or objects in an evolutionary order, reflecting the successive changes (improvements, modifications, alterations, changes, etc.).

– Generation: Object or concept, specific to a given period, that is perceived as having a conceptual unity in time.

– Evolution engine: Driver (not necessarily causal) of the evolution from one generation to another.

– Rationale: The set of elements, positive and negative, provided by a generation.

– Example: Lineages of Coherent Anti-Stokes Raman Scattering (CARS).

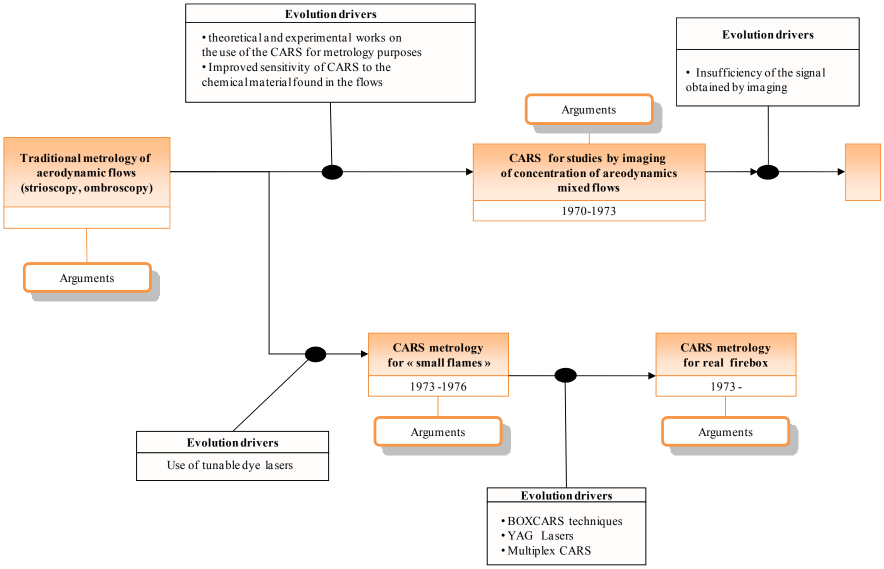
Figure 9.9 shows an example of lineages taken from a study conducted at the *Office National d'Études et de Recherches Aérospatiales* (ONERA) by Jean-Pierre Taran and Philippe Benhamou. It consisted of reconstructing the history of the evolution of a measuring technique designed at ONERA and considered to be particularly innovative for around 50 years.

CARS is a physical phenomenon at the basis of a method for measuring temperature and gas concentration used at ONERA. This method consists of irradiating a sample with a mix of two laser waves whose frequencies differ by a value equal to the frequency of the vibration in the gas to analyze. The analysis and the measurement of the intensity of the beam produced by the CARS effect provide information about the temperature of the sample and its gas concentration.

The history of the development of the CARS at ONERA is the history of a major technical innovation. It began at the start of the 1970s when a researcher had the idea to apply a measurement method that was up until that point entirely focused on crystallography and molecular biology to one of the major areas at ONERA, namely the metrology of turbulent runoff.

This technology gave rise to a measurement device that was quickly patented, then to several evolutions involving both the improvement of the technology (improving detectivity, integrating data processing, etc.) and the expansion of the domain of application.

Figure 9.9 shows a diagram and a graphic syntax to model a lineage tree, notably making it possible to codify expert discourse.



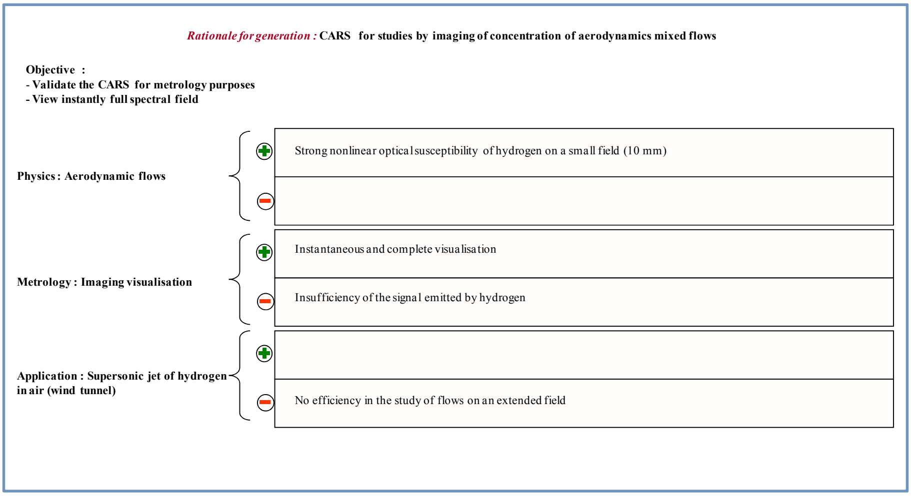


Figure 9.9. *Example of a lineage model*

9.3.3.4. *Conclusion about knowledge books*

The knowledge models that were described in detail here have been up until now used in companies as tools to analyze and structure tacit knowledge through expert discourse.

In the process of designing knowledge books, these models are realized through "co-construction" with an expert (or several experts), during one-on-one interviews with a knowledge engineer. Of course, the process is not linear, and modeling knowledge is not done in a series by constructing each model one after another. The series of interviews is guided by a table of contents in the book that is determined at the start of its design. This table of contents is unique to the knowledge domain and does not at all determine the knowledge models to use. The appropriate model (sometimes several models are necessary) for each chapter is discovered during the interview or even determined after the interview. The construction of a knowledge book occurs gradually and is never determined in advance.

The advantage of the knowledge modeling technique is its structuring and explanatory power, which surpasses by far all of the technical writing techniques that only use written language and specific schematizations. However, the construction of models should not be reduced to the creation of diagrams. It must structure an entire set of relevant information that completes the elicited schema: pertinent comments (the "yellow squares" attached to the model in the graphic examples provided), attached documentation, images, supplementary information, videos, bibliographic references, etc. This information is sometimes very abundant and it is always attached to a knowledge model or an element in this model, so much so that the knowledge book becomes hypermedia (websites or other) whose main pages are knowledge models that present hypermedia links toward useful information sources. A printed form of a knowledge book is therefore not the best form to give as the final result, contrary to what the name "book" may imply (inherited from the history of the technique).

The knowledge book must be designed as a complete information framework structured around a given knowledge subject. Its most natural form is a hypertext document. This requires that it be designed with care, respecting the rules of ergonomics for reading such as navigation and readability that depend in part on the technology used (web technology, hypertext technology, PowerPoint slideshow, etc.).

A company that systematically creates, with a medium or long-term knowledge capitalization strategy, a library of knowledge books about all of its critical knowledge (or one of its subsets), possesses a materialization of a crucial part of its knowledge capital, which will allow it to preserve, transmit and evolve its precious knowledge resource, so long as these "books" do not remain a "library" and serve as a support for the processes of sharing, transferring and evolving which will be described in the following sections.

9.4. Knowledge sharing

– P2: Maintaining the knowledge capital and ensuring its application

- P2.1: Formalizing and making knowledge available

    - Sharing knowledge (collaborative work, social networks, etc.).

- P2.2: Ensuring knowledge application

9.4.1. *Knowledge communities or communities of practice*

In practice, in all organizations, people interact with one another, creating the conditions for the circulation and dissemination of their tacit knowledge without necessarily resorting to codification. Very often, this leads to the creation of social networks of specific knowledge, and communities of people who share a certain knowledge capital. It is therefore becoming essential for organizations who want to manage their knowledge to organize these knowledge networks and support their operation.

In KM, in companies, the most popular form to implement the process of sharing knowledge is the use of “communities” that are very particular social networks. There are many types of communities and many definitions. Here are two main definitions:

– A knowledge community is a group of people in a company who are involved in knowledge-sharing activities with a common work objective (shared responsibility of a process, product or service, a project, etc.). The knowledge community can include people from different disciplines in the company and even participants from other companies or the nearby environment (service providers, logistical partners, customers, etc.).

– A community of practice is a group of people who share a mutual professional interest in a practice and who interact regularly to learn how to improve in their practice.

Not all groups of people or all social networks with a common interest are necessarily a knowledge community or a community of practice. Most networks of people in a company are essentially constituted to exchange information.

Historically, the notion of a community of practice was developed by the anthropologist Jean Lave [LAV 91a], who collaborated with Etienne Wenger who made it a widely used tool in KM [LAV 91b, WEN 98].

Communities of practice are structured by three dimensions:

– Mutual commitment: All members of the community must respect this commitment. Trust and openness to others are essential characteristics. The main objective of the mutual commitment is that everyone helps and is helped by another member of the community.

– A common area of interest: A community is not simply a network of connections between people. It has an identity defined by a shared area of interest, a common undertaking. Belonging to the community implies a shared commitment to a company objective and its evolution based on the new challenges and problems that appear.

– A common capital: The members of a community are competent practitioners. They develop a share directory of resources: experiences, stories, vocabulary, procedures, files, tools and ways to address recurring problems. This requires time and sustained interaction.

For the notion of knowledge community, there is an introduction in element no. 6 of the BourbaKeM treaty [COH 14].

Here again, there are three dimensions, similar to the ones mentioned previously, that structure knowledge communities. A knowledge community is an informal group (which must be properly distinguished from formal modes such as functional groups or project teams) of members characterized by the following properties:

– the behavior of members is characterized by the voluntary commitment to the construction, exchange, and sharing of a repository of common cognitive resources;

– through practice and repeated exchanges, the members of a given community gradually construct a common identity;

– the knowledge community bond is ensured by respecting the social norms specific to the community.

A combination of these three characteristics determines to what degree the community's knowledge sharing is effective.

The right tools can significantly enhance the community's performance. A complete range of communication and collaboration tools can create the conditions for efficient knowledge sharing, mutual learning and problem solving in the whole community.

Creating a community to share knowledge is not easy. There are many failure factors. Particular attention to the structure and operation of the community is necessary to manage this type of knowledge network.

With this in mind, the French KM Club offers a tool to evaluate a knowledge community called the *Community Maturity Model* (CoMM) which makes it possible to assess the maturity of a knowledge community and identify its needs to ensure its development and sustainability. This model evaluates knowledge communities based on the characteristics that were previously described. Therefore, it is intended to:

– verify the structural foundations of the community in question;

– decide on their stages of development or degree of formalization (emergence, structure, maturity, consolidation, etc.);

– identify gaps, flaws, needs and risks for the development of the community;

– determine action plans and management processes based on the community's stage of development;

– define the collaborative tools that are appropriate for the working methods between members.

CoMM is an analysis grid with 18 criteria divided among the four following areas:

– shared initiative: everything that makes a community an independent entity: practices, objectives, interests, etc.;

– mutual commitment: a relationship of mutual assistance between the participants, necessary for sharing knowledge. This also includes carrying out actions and operations to maintain the necessary coherence in a knowledge community;

– shared capital: the set of information capital created, adopted and shared with the community, which allows its members to create new knowledge based on the situations and interactions in which they find themselves;

– collaborative work: collaborative activities and processes conducted by participants within the community with the goal of sharing their knowledge and experience. This also includes the methods and support tools that support them.

Each criterion is evaluated on a scale from 1 to 4. To facilitate the analysis and notation, the levels of each criterion are described succinctly, with as many examples as possible.

The analysis grid of a knowledge community is detailed in Table 9.1 as well as Figures 9.10 and 9.11.

Main topics	Criteria
Shared initiative	1. Legitimacy 2. Missions 3. Common areas of interest 4. Knowledge creation
Mutual commitment	5. Membership 6. Code of conduct 7. Motivation 8. Level of participation 9. Mutual trust
Shared capital	10. History 11. Common framework 12. Information capital 13. Common values 14. Identity
Collaborative work	15. Communication 16. Animation/coordination 17. Collaboration/cooperation 18. Collaborative tools

Table 9.1. *Grid of CoMM criteria*

TOPIC SHARED INITIATIVE
Criteria 1 Legitimacy

How can the knowledge community perceive itself as legitimate?

Level 1 External legitimacy of the community
The community is imposed from outside but members do not feel involved.

Level 2 Internal legitimacy of the community
The community develops solely through members commitment.

Level 3 Internal legitimacy and external benign neutrality
The community develops and is accepted by its environment.

Level 4 Internal legitimacy and external value
The community develops itself, is recognized and benefits from evolving.

Figure 9.10. *Example of CoMM criteria*

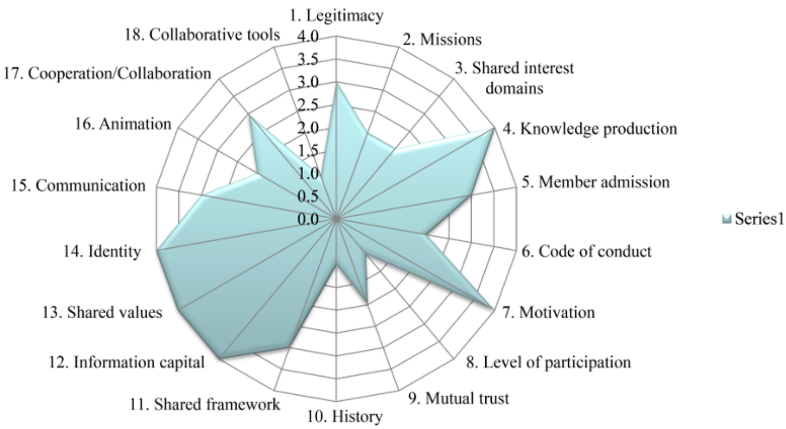


Figure 9.11. *"Signature radar" of a community following an evaluation with the CoMM grid*

9.4.2. *Knowledge transfer*

9.4.2.1. *Introduction*

Knowledge transfer is the practical problem of transferring knowledge from one part of the organization to another. It is intended to organize, capture, create or disseminate knowledge and ensure its availability for future users.

Knowledge transfer can be understood very broadly, sometimes even as equivalent to KM. Here, it will be considered as a process that includes a set of interactions between individuals and groups to communicate and share knowledge, such that the end users of the knowledge acquire the comprehension and capacity to apply this knowledge.

Before being implemented, a knowledge transfer process must be clearly defined in terms of:

– justification of the need for knowledge transfer;

– knowledge to be transferred;

– expected advantages and success indicators (to measure the effectiveness of the knowledge transfer);

– context of the knowledge transfer;

– actors (knowledge holders, knowledge recipients, etc.).

The process of knowledge transfer can be illustrated by the knowledge model shown in Figure 9.12.

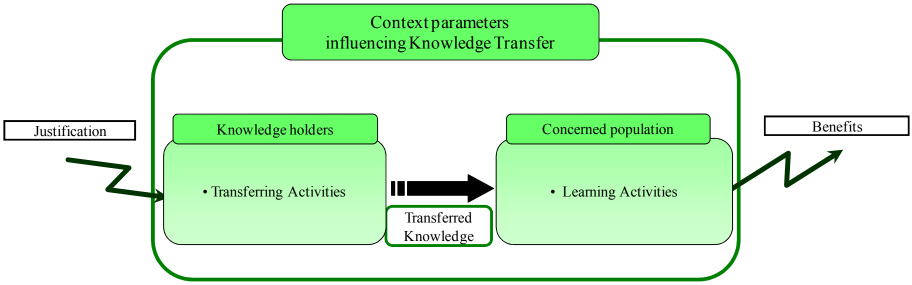


Figure 9.12. *The knowledge transfer process*

There are many knowledge transfer methods and processes. Because of this, choosing one or more knowledge transfer processes in a given context has become difficult. Here, we will revisit some of the elements of the French KM Club's "Knowledge transfer" commission (which was directed by Patrick Coustillière) that it is important to customize based on the expectations, project specifications and environment.

9.4.2.2. *Criteria options for a knowledge transfer process*

Several criteria can be helpful in decision-making. Based on the model shown in Figure 9.12, a few useful criteria are detailed.

9.4.2.2.1. Context parameters influencing knowledge transfer

Implementation deadline: date or time after which the transfer must be effective and knowledge must be operational;

– asynchronous context (the source and target do not intersect);

– organization size;

– dedicated material resources (budget, room, video projector, PC/tools, etc.);

– training resources, tutors (internal or external), mediators to channel available expressions;

– level of information and communication technology equipment;

– accessible document corpus.

9.4.2.2.2. Transferred knowledge

– Rare knowledge that cannot be substituted;

– operational knowledge (vs. cultural);

– consolidated and stabilized knowledge (easy to capture);

– adaptable knowledge depending on the context of application;

– knowledge that is difficult to integrate into daily use (acquisition of reflexes, code of conduct);

– number of specialties contributing to the knowledge.

9.4.2.2.3. Knowledge holders (transfer actors)

– Number of actors holding the knowledge;

– availability;

– motivation;

– geographical distribution: (one site, several sites, one country, several countries, etc.);

– training and professional experience;

– ability to listen, express and make the knowledge understandable.

9.4.2.2.4. Target population (learning actors)

– Number of target actors;

– availability;

– motivation;

– geographical distribution: (one site, several sites, one country, several countries, etc.);

– level of knowledge and experience with the subject prior to transfer;

– homogeneity/generation/characteristics of actors;

– homogeneous activity profile;

– ability to concentrate/autonomy.

9.4.2.3. *Some examples of knowledge transfer frameworks*

9.4.2.3.1. Training

Face-to-face learning
Objective: To transmit theoretical knowledge to a homogeneous group of people who are physically present in the same room as the trainer. Description: – The trainer and the trainees are physically present in the same place of learning, which does not exclude the personal work of the student in session and intersession. – The training time is limited, often as short as possible. – Adequate framework for practicing role playing and group work. – Transfer process is difficult to implement: Homogeneity of trainees, planning difficulties, absenteeism, room logistics, etc. Comments: – Requires as homogeneous a group as possible to avoid excessive comprehension discrepancies between trainees. – Allows for exchanges between different trainees. – This is an opportunity to create links between actors and expand their network.

E-learning (autonomous)
Objective: To acquire knowledge independently and remotely using electronic media and evaluating the knowledge acquired. *Description:* – The trainer is totally absent from the framework and the process. – The student is alone with the computer. – Through the use of new information technologies, educational objectives and scenarios are made available for an area of knowledge to transfer.

Comments:

– Requires the implementation of technical supports that must be mastered by the trainees.

– Adapted for:

- Office training, software and software package where reflexes must gradually be acquired (Process, action).

- Technical training or complementary operations on a subject that is already well-mastered by the student (i.e. the characteristics of a new product in a known range).

– Not adapted:

- if the objective is the discovery of an unknown or little-known subject;

- if the objective is an awareness of a behavior to modify (behavioral capacities);

- if the target has a low level of motivation.

E-learning (tutored)

Objective:
To acquire knowledge in a defined learning environment, remotely, using electronic media and evaluating the knowledge acquired.

Description:

– Remote guidance and monitoring with a tutor. Contact with the tutor can be live (synchronous) or delayed (asynchronous).

– Educational objectives and scenarios are made available for the knowledge area to be transferred.

– Framework (platform):

- remote exchanges with the trainer;

- access and availability of content/exercises/corrections.

Comments:

– Requires technical supports that must be understood by the trainees.

– Guides, secures and stimulates the student in order to reduce dropouts.

– Does not allow for sharing/exchanges between different trainees.

Virtual classes

Objective:

To transmit theoretical knowledge to a homogeneous group of people who are gathered together but not physically present in the same place.

Description:

– The trainer and the trainees are virtually present: use of collaborative tools.

– Personal work by the trainee between sessions is not excluded.

– The transfer method requires trainees at a similar level.

– The duration of training sessions is limited: concentration, mobilization of resources (maximum recommended duration for one session: 1 h 30 min).

Comments:

– Requires advanced collaborative tools (whiteboard, real-time document sharing, audio, video, etc.). The use of these resources must be mastered by the participants (trainees and trainer).

– Allows for interactions with the trainer and other students.

– Avoids travel and associated costs (multisite, multicountry, etc.).

– Reduced logistics organization (rooms, meals, etc.).

– Involves the simultaneous availability of each trainee for the training sessions (pay attention to time zones, etc.).

– Is less friendly than a face-to-face session, which has the advantage of creating connections between the actors and thereby contributing to building their networks.

– Is not well-suited for role play games.

9.4.2.3.2. On the job training

On the job training is the process of acquiring practices and knowledge in a situation through observation, imitation and repetition.

Mentoring or tutoring

Objective:

To acquire a specific expertise from a master (or expert).

Description:

Knowledge transfer through an individual relationship culminating in the integration of the mastered expertise. The acquisition of practices and knowledge occurs through observation, imitation, repetition and interaction with the expert.

Comments:

– Training character and attitudes are indissociable from learning the technique.

– Quality of the link in the educational relationship as conditioning the deep roots of knowledge.

– Occurs in relation to specific tasks.

– Occurs accompanied by an experienced person (specialist, expert, etc.).

– Not intended for novices: intended to perfect and deepen experience.

Work-based/school-based learning

Objective:
To acquire expertise through a significant corporate experience.

Description:

Work-based/school-based learning is a training system that combines theory and professional experience in companies. It allows young people to integrate into the professional world while pursuing their studies to obtain a diploma or a certified title.

Comments:

– This formula is attractive for the company because it prepares young people to practice a profession directly related with the company's requirements.

– Inexpensive for the company.

– Provides the company with an outside view.

– Planning imposed by the school.

– Time needed for mentoring, evaluating work and commuting.

Educational games/role playing

Objective:

To acquire experience through a scenario based on a simulation exercise or role-playing game between several members of a group.

Description:

– The scenario exercise allows for observing, handling and understanding technical or economic problems or relational situations that are generally complex.

– Role-playing game allows participants to identify with characters based on a previously decided scenario.

Comments:

– The role-playing game brings certain disciplines to life: it transforms the learning situation to the benefit of the student who becomes active.

– The role-playing game clears up some resistance.

– It gives the individual a greater degree of freedom to gain experience.

– In the training context, it is not recommended for a protagonist to play a role they are familiar with during the game.

– The role-playing game does not authorize the action in real life.

9.4.2.3.3. Knowledge networks

Project group (includes work group)

Objective:

To accomplish a specific project (a common task) completed by a group of appointed people within a given timeline with temporary resources to acquire and share knowledge.

Description:

The leader and the members of the group interact to accomplish the set objective, each according to their competences and the roles assigned to them.

Operating condition:

– Assignment of a mission: objectives, task, role and defined deliverables.

– Designation of a leader who ensures the result.

Comments:

– Interactions with other elements of the organization are elicited.

– Corresponds to a temporary organization.

– Importance of interpersonal links or joint intentionality.

Community of practice

Objective:

To share, develop and improve professional practices with people that have the same activities and a common understanding and give the same meaning to this activity and the community. To act as a support network, notably mentoring.

Description:

A community of practice includes people who share the same professional practice. It is a voluntary commitment to a collective project whose meaning is negotiated with others. Although controlled by a formal hierarchy, it self-regulates according to its values and beliefs. It is equipped with physical resources (especially computer resources) that make it possible to share collective works in light of the negotiation of meaning involved in it (reference elements). It reflects the shared learning (at first peripheral participation that increases in commitment and complexity).

Operating condition:

– Sympathy and commitment to a common cause (engages the individual's personality: mutual definition of identities).

– There is no hierarchical relationship in the community; members are peers (no leadership).

– Balance to be found between imposing an institutional structure on the community and emerging a structure of practices (contributing to its coherence).

Added value:

– Main way to manage critical and tacit knowledge: animating social structures responsible for learning, retaining and developing skills.

– Human resources are at the heart of the strategy (talent management, faster problem solving, wealth of perspectives, encouraging risk-taking, trust, organizational learning, etc.).

Comments:

– Small informal groups (heterogeneous social forms: organization, association, profession, etc.).

– Boundaries with the organization: fairly vague.

– Autonomous individuals.

– Mutual commitment is based on skill complementarity (members can have very different levels of expertise).

– The presence of a computer is a real plus.

– Difficult to create and manage the community (interaction process supposes transactions, negotiations and some conflicts).

Expert network

Objective:
To collect and share information between experts who have a common interest.

Description:

The expert network is an informal, voluntary group.

Here, we consider the case of knowledge transfer and sharing internal to a company.

Comments:

The boundaries with the organization are vague.

9.4.2.4. *Conclusion for knowledge transfer*

There are many types of knowledge transfer processes. They can consist of a transfer from one person to another, from a person to a group, from a group to another group, within a group, etc. A transfer does not necessarily occur in a given direction, from an utterer toward a recipient. This can depend on the knowledge transferred and the context of the transfer. It is important not to confuse the transmission of information with the transfer of knowledge. There are many parameters to consider, which make knowledge transfer a complex phenomenon.

As a result, there are countless methods for transferring knowledge within a company. Many are traditional, and have been in place for a long time in companies. Others are in development, or emerging, especially due to the arrival of new digital technologies. KM must take all of this diversity into account. It can propose and manage a certain number of innovative transfer methods, but above all, it must monitor that the methods implemented are oriented toward the company's knowledge capital management, by ensuring that the method works on an identified and evaluated part of the capital, and by appreciating its impact on the knowledge of the intended target audience. It is by providing added value to the company's global knowledge capital that all knowledge transfer processes fulfill their objectives in the KM sense.

9.5. Knowledge search

– P6: Transforming external information into useful knowledge for the company

- P6.1: Managing and supervising environmental scanning systems (competitive, strategic, technical, etc.) in connection with KM

- P6.2: Organizing the collection and interpretation of information from the external environment

9.5.1. *Knowledge search and information retrieval*

The expression “knowledge search” is an extension of the expression “information retrieval”, which is a process that is known and mastered in many companies. In KM, knowledge search (also called “knowledge acquisition”, but this term is often used with much broader definitions) refers to the knowledge that a company collects from external sources (and in some cases, internal sources). These sources include suppliers, competitors, partners/alliances, customers, external knowledge networks, etc. Knowledge search is based on the collection of information from a wide variety of information and knowledge resources. The goal of the knowledge search process is to transform this information into useful knowledge for the company and integrate it with the existing knowledge capital. The way in which the information will be collected will depend on the quality of the knowledge produced.

Knowledge search is a systematic process of collecting, analyzing and exploiting useful information for generating knowledge in a company.

Two well-known processes fall under knowledge search:

– Science and technology watch.

This is a process implemented to observe, monitor, filter and evaluate scientific and technological advancements in the domains that interest the company, but that extend beyond the boundaries of what it is currently concerned with. The watch process must be able to identify all scientific and technical knowledge that is useful for innovation in the company. This process can be divided into four main phases: needs analysis, information retrieval, information processing and the integration and dissemination of results.

– Environmental analysis (strategic and competitive scanning).

This is a process of studying and interpreting political, economic, social, technological, environmental and legal factors that influence the company (events, trends, challenges and expectations of different interest groups). This analysis must detect the signs of trend breaks and major changes in the organization's knowledge resources (for example a change in societal values, an innovative new technology, a paradigm shift, etc.). An environmental scanning process addresses the collection and analysis of information about events and their relationships in environments that are internal and external to the company.

A knowledge search process is articulated in three main phases:

– An analysis of information needs and the formulation of requests.

Once the information needs are defined, this consists of matching them to the (perceived or perceptible) environment. It is translated by requests that must be addressed to the informational environment of the company.

This is a knowledge-based phase, which is founded on the state of the art of knowledge in the domain concerned in the company. In general, the intervention of experts in the domain makes it possible to reformulate the initial question (which is often misguided) with new points of view and optimize the knowledge search process.

– Information retrieval.

This phase ranges from the collection of information based on the requests formulated to the elaboration of the information corpus.

– Knowledge creation.

This consists of synthesizing the information corpus obtained by creating a comprehensible and shared representation and starting a process of interpreting and creating knowledge that must be useful for the company regarding the objective intended by the knowledge search process. Naturally, this is a knowledge-based phase.

These three phases are organized in a five-step process described in Figure 9.13.

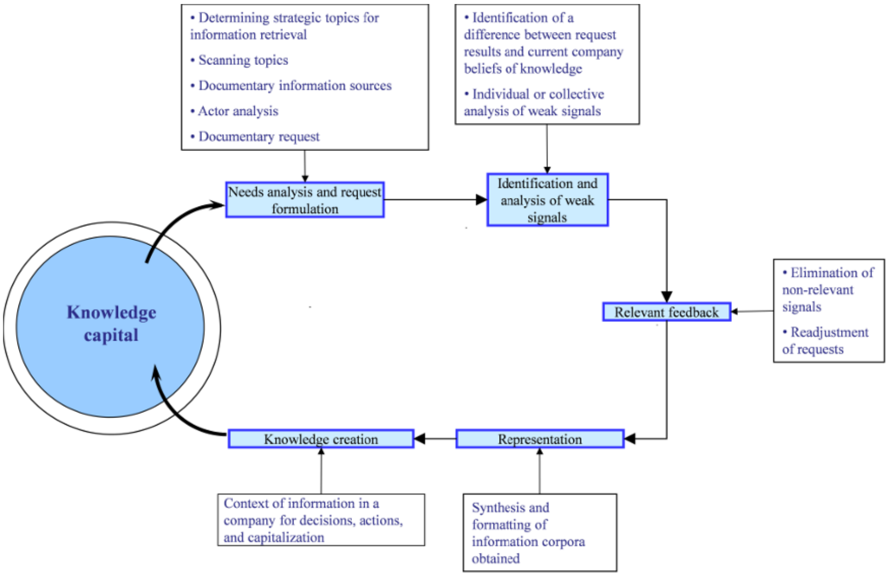


Figure 9.13. *The knowledge search process*

9.5.2. *The knowledge search process*

9.5.2.1. *Needs analysis and query formulation*

This is the mapping of the representation (explicit or tacit) of knowledge in the company by its actors with the perceived or perceptible environment.

For example, according to recent cognitive studies about the decision-making process, the representation that the decision-maker makes of the environment is tacit, not always precise and justified, and the resulting mapping is intuitive and personal.

In a more methodological and collective approach, this mapping can occur through the construction of an explicit and simplified representation of knowledge: information retrieval filters, information retrieval profiles, documentary requests, etc. It can also occur through the confrontation of tacit representations within the organization through "monitoring groups" (mostly experts) who formulate questions that are then transformed into information retrieval queries by specialists (researchers, monitoring specialists, etc.).

Once the queries are formulated, the information sources that will be interrogated must be determined (bases, data banks, web, etc.). This can be completed by analyzing actors, such as competitors, suppliers, research centers, partners and internal actors likely to have information about certain axes and be able to address them.

A relevant expression of needs in information retrieval also makes it possible to establish the specifications containing the (re)presentation of knowledge in the domain, the information retrieval queries validated by this representation, and the formal and informal information sources determined by these queries. Computer tools are then used to collect the corpus of information from these queries and these sources.

9.5.2.2. *Identifying and analyzing weak signals*

This is the elicitation of singular points, or "weak signals", that we detect in the information collected. These are signals that indicate that there are "interesting and potentially new things" in the company's environment that could be useful to it.

These weak signals must be elicited and documented to be able to trigger the next steps.

The analysis of weak signals may very well not be elicited or argued at all or minimally; it can lead directly to an intuitive decision that may be revealed not to be based on what follows.

In a collective approach, in vast domains, the manifestation of interesting weak signals in the environment is necessarily done by a distributed interpretation, notably with groups of experts, and is not followed by immediate decision making, because the next step gets underway.

9.5.2.3. *Relevant feedback*

This is the elimination of weak signals that are not relevant and the in-depth study of relevant signals. From a personal point of view, it is simply common sense. However, for a large corpus of information, it is necessary to analyze by brainstorming and/or exploring with information tools, by launching a gradual adjustment loop of queries based on the analysis.

In information retrieval, with current technologies, we often gather a large number of informational documents. This corpus has two characteristics: noise (non-relevant information) and silence (relevant information that is not captured in the search). The objective of relevant feedback is to decrease the noise and reduce the silence as much as possible.

9.5.2.4. *Representation*

This step consists of constructing representations that are reading grids adapted from the information corpus obtained. These representations are constructed using mathematical (statistics, etc.) and/or cognitive operations (diagrams, symbols, images, etc.). In an intuitive approach, if the relevant feedback is adequate and appropriately sized, there can be a global perception that is natural and sufficient for a suitable action. However, without a method, the risk of having a linear reading and an information overload is high, resulting in a random reading grid that can lead to other misleading actions. In a more equipped approach, the representation can be obtained, for example, with so-called "infometric" tools or collectively with targeted readings by groups of experts.

9.5.2.5. *Knowledge creation*

This step includes the creation of information and new knowledge for the company. It consists of cross-referencing information and implementing interpretation and knowledge creation processes that permit a decision or an action based on the representation of the environment resulting from the steps described previously. It is a very poorly understood process at the heart of the problem of knowledge-based companies. It is a sort of creation of collective meaning that requires a great deal of further explanation.

9.5.3. *The challenge of KM in knowledge search*

As we can see, two steps are in direct synergy with the company's knowledge capital and its actors: the step of formulating needs at the start of the interaction with the environment, and the step of creating knowledge, at the outcome of the collection of information from the environment.

The step of formulating needs concerns the knowledge capital because it is necessarily the internal vision of the company that is being connected with the external world. This internal vision is based on the beliefs and reputations that prevail in the organization. These are necessarily based on the culture and knowledge specific to the actors. It is therefore part of a company's knowledge capital that plays a role in this operation. It would be all the more effective if the capital was better known and better exploited. Here, we find the common sense rule “know yourself”: to better understand what surrounds us, it is necessary to know ourselves well.

The step of creating knowledge involves enriching the tacit or explicit knowledge capital. It is still mysterious, however, how is new knowledge that is useful for the company created, when observing the environment? How is creativity realized, or capacities for innovation? How does the company organize this creation with other similar internal functions? How does it capitalize on this knowledge in its capital?

These two steps, which largely fall under the purview of KM, are currently the ones that are least controlled by the process of knowledge retrieval. Some observations can be made about these steps:

– in the needs analysis step, there is a real difficulty for experts and managers to precisely define their information needs. Often, as has been demonstrated by many studies, the tendency to reduce the scanned environment by too much creates a risk that a company will not see certain opportunities or threats emerging in their environment.

– in the knowledge creation step, the traditional process of information retrieval is often reduced to three steps:

- information retrieval;
- processing the information collected;
- storing and disseminating the information processed.

As we have already noted, the effectiveness of this step can be optimized by mechanisms that would facilitate the passage from a state of information to a state of knowledge. Such mechanisms are not yet very developed.

KM can provide some added value to environmental scanning activities that are often strategic for a company. A relevant questioning can be supported by good management of the existing knowledge capital in the organization, and the analysis of external information can translate into useful and operational knowledge if we realize this analysis by mobilizing existing knowledge actors and capital that it will enhance.

9.6. Knowledge creation

– P4: Supporting creative systems

- P4.1: Supporting the innovation process
- P4.2: Supporting the creativity process

9.6.1. *Knowledge creation and innovation*

The capacity to create new knowledge is often at the core of an organization's competitive advantage. This capacity is strongly linked to innovation and is often seen as an integral part of the innovation process when it is recognized and supported in the company. From a KM point of view, the process of creating knowledge is the part of the innovation process that requires KM support because it is heavily based on knowledge.

The body of literature about the innovation process in organizations is immense. It is impossible to provide an exhaustive description. However, most models and methodologies propose, in part or in whole, a process of eight phases (Figure 9.14):

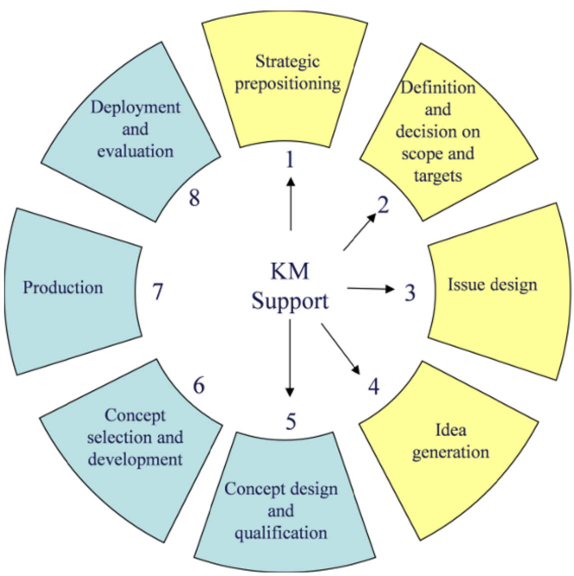


Figure 9.14. *The innovation process*

1) Strategic prepositioning: choice of innovation as a strategic topic by creating conditions that are favorable for its deployment: scanning and observing trends centered around the technical, commercial, environmental, use, etc.

2) Definition and decisions on scope and targets: analyzing market needs, defining targets and priorities, determining the scope and the environment of the problem.

3) Issues design: sharing problematics between research and marketing, scripting and developing orientations, anticipating opportunities and risks, identifying success factors.

4) Idea generation: implementing creativity methods and techniques, innovative design approaches, disruptive search.

5) Concept design and qualification: transforming ideas into concepts, evaluating them in terms of their value, quality and timeline.

6) Concept selection and development: selecting projects, studying their feasibility, defining the output products, their ecosystem and the production process.

7) Production: designing, completing and testing products, mocking up and prototyping, industrialization, organizing production.

8) Deployment and evaluation: protecting the innovation, dissemination, evaluation of market introduction.

Only processes 1 to 5 are related to KM processes. For example, the first process requires the support of a knowledge retrieval process, as was addressed earlier.

Processes 4 and 5 address creativity and inventiveness, which are two parallel activities: “idea generation” on the one hand and “design and qualification” on the other. Creativity corresponds to generating ideas and inventiveness corresponds to creating knowledge from these ideas (design knowledge). There is often no distinction between creativity and inventtiveness. The creativity techniques practiced in a company are often not correlated to both the existing knowledge and the creation of new knowledge, materialized as new knowledge resources (such as patents or documents).

9.6.2. *Knowledge-based innovation*

9.6.2.1. *Definition*

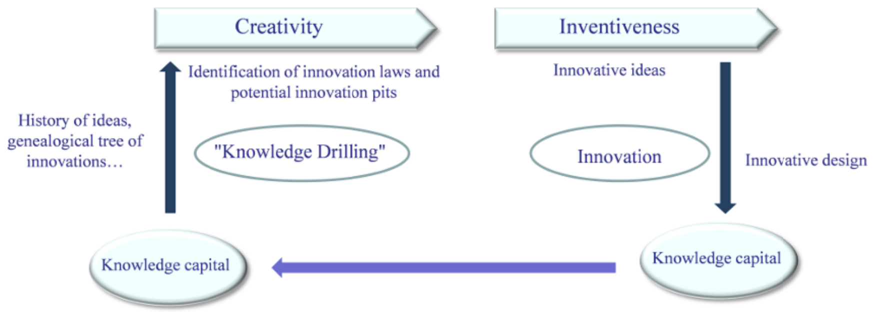


Figure 9.15. *The knowledge-based innovation process*

The correlation between creativity and knowledge resources in a company is called knowledge-based innovation [SAU 02]. Knowledge-based innovation follows the process illustrated in Figure 9.15.

The knowledge-based innovation process has two main phases:

– *Knowledge drilling* (or "knowledge archeology") as a support for creativity.

Creativity is the evolutionary process of knowledge in a company. The evolution of ideas follows the guidelines defined by past developments, along knowledge trajectories that can be traced by analyzing knowledge resources: choice, decisions, discoveries, lessons learned, etc. that were produced in the past. *Knowledge drilling* is a detailed analysis of the history of past ideas and innovations that led to significant changes in the organization or that were rejected for some reason. The analysis of this history is then extrapolated to identify some potentially useful ideas for future innovation.

There are many creativity methods, but only a few are based on knowledge drilling. The most popular creativity tools, with many classic methods, are brainstorming methodologies. They include a phase of divergent thinking (distancing from the problem at hand, calling on subjectivity, analogy and imagination to come back to the problem later from a different angle) and a phase of convergent thinking (transforming ideas into solutions that respond to the initial problem using logical reasoning).

An example of a knowledge-based knowledge creation method to solve problems is the famous TRIZ method, a Russian acronym for the *Theory of Resolution of Inventive Problems*, developed by G.S. Altshuller in the 1980s [ALT 84], dedicated to the resolution of technical problems that require innovative solutions. This method shows that, faced with such a problem, it is possible to find inspiration in other domains to solve similar problems. TRIZ is the archetype of the knowledge-based innovative design method. The knowledge drilling technique used is sophisticated because the method accounts for the existing ideas in databases of millions of patents.

Creativity methods do not *a priori* provide a means of realizing the chosen method. A supplementary process is required to provide a design and innovative knowledge that can be patented as an invention. This is the process of inventiveness:

– *Creation of innovative knowledge* as a support for inventiveness.

Inventiveness is a process of transforming creative ideas into effective knowledge in order to design new products, new services, improvements, etc. It often involves the activity of research and development. It is a key process for KM because it elicits effective knowledge (documents, studies, patents, etc.) that must be capitalized on as new knowledge resources.

9.6.2.2. *A creativity process before innovation*

Here, we are describing a creativity process that occurs before the knowledge-based innovation process based on the representation of explicit elements of the inventive part of the knowledge capital obtained by knowledge drilling. This representation is then used to prompt reflection by knowledge actors about the potential evolution of knowledge in several domains concerning the specific domain of their company.

In the next phase of the process, the prospective elements obtained are successively presented to different groups, technical peers, other experts in the domain, representatives of technical strategy and representatives of company strategy. This is a collective co-construction resulting from the constructive reflection of participants based on their past and current knowledge. This phase is intended to strategically align the results of the co-construction by placing all prospective elements in the perspective of the medium- and long-term strategy of the company.

The last phase is the dissemination of the prospective vision to the knowledge communities of different domains for a shared vision of the future and to the innovation managers to transform prospective ideas into operational knowledge to design innovations.

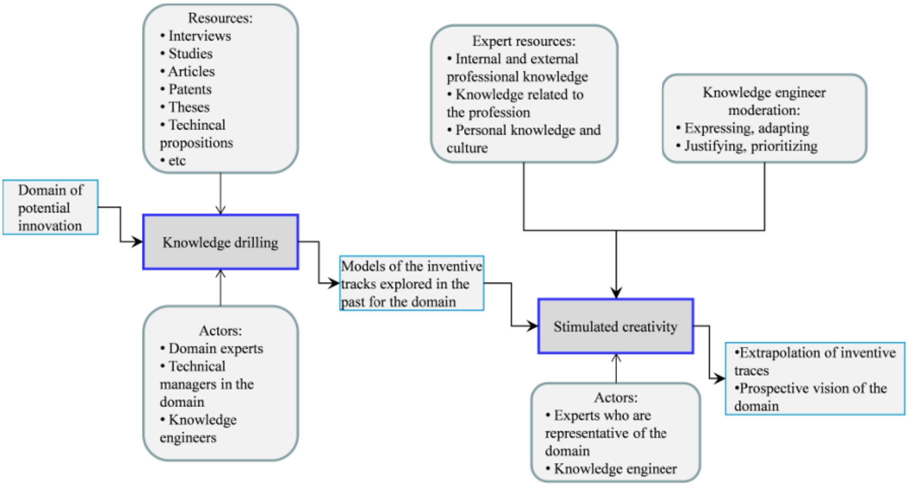


Figure 9.16. *The stimulated creativity process for each expert in the domain*

– Step 1 (Figure 9.16).

Everything starts with the effort of knowledge drilling, which can be a lengthy and fastidious process. Its goal is to seek inventive paths from the past decades in the explicit knowledge capital (patents, articles and documents, study reports, internal notes and white papers, presentations, training material, etc.). The paths are dated and attached to one of the knowledge domains of the subject (NOTE.– To structure a given subject in knowledge domains, a consensus is required, which can be difficult to obtain. For example, dividing a technical object into different knowledge domains corresponding to professions or distinct competences is not an easy task).

The inventory and analysis of inventive paths can be a time-consuming activity because it must be as complete and as objective as possible. This requires that experts or specialists provide an initial list of the main contributions in their domain, complemented and amended in questioning and elicitation interviews. In general, to document these paths, the justifications are unfortunately dispersed in different forms, in different places, and sometimes, they are even lost.

A summary model of inventive paths is constructed based on this corpus. Models like knowledge maps, historical time charts or genealogical trees of lineages can be used.

– Step 2 (Figure 9.16).

After the first step toward reconstituting the inventive paths, we conduct individual sessions of stimulated creativity with recognized experts in each domain in question. These sessions start with a presentation to the expert of the inventive paths explored in the past in the domain, the result of the previous step. These paths are then analyzed by the expert who then extrapolates from them and thereby elicits a prospective vision of the domain. The usual duration of these sessions is half a day. A summary of each session is then made, resulting in a prospective document validated by the expert and including:

– the presentation of the domain;

– the initial analysis of prospective paths in the domain;

– the expert's comments about the initial analysis;

– the prospective vision suggested to the expert by the current state of the paths;

– a summary made by the expert.

– Step 3 (Figure 9.17): Co-construction of the prospective.

The prospective elements are successively presented to different groups:

– peers, who must react to the prospective technical material proposed by the domain representatives;

– experts in the field, who know how the technical object operates on the customer site, whose role it is to provide the technical perspective of the customer;

– actors in the interdisciplinary technical strategy, whose role is to state the technical policy of the organization or a technological field;

– strategy actors, whose role is to provide marketing elements and product policy.

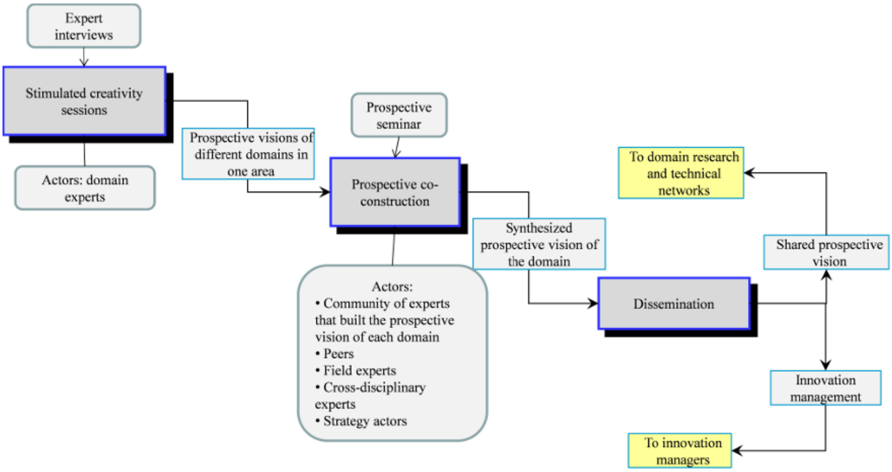


Figure 9.17. *The creativity process*

This interaction is generally organized during a 1-day strategic seminar. The experts who constructed the prospective vision support their prospective vision of their own domain, but highlight and discuss the links between all domains, in particular the boundaries of the domain by merging the prospective visions. Other experts provide their own contributions to the discussions: a result is provided by experts in the technical domain, who discussed the opportunity for future innovations based on the point of view of their customers and end users. A contribution to the strategic alignment is made during the seminar.

The seminar report includes, for each domain:

– the focal points; the major problems that determine future challenges;

– for each focal point, the action plans to implement based on the current situation and environment as well as future trends.

– Step 4 (Figure 9.17): Dissemination.

This consists of disseminating and sharing the previously constructed synthetic prospective vision with communities of technical experts and with management and leaders of innovation in companies. The intended objective is to make technical, commercial and strategic propositions for the development of innovative products or services in order to lead the innovation process to its final stage.

9.6.3. *Evaluating the maturity of the innovation process*

To ensure their sustainability and the competitiveness, companies must support their innovation process. As we have seen, as a creative process, this process has two main components: creativity and inventiveness. KM is a lever in the service of a voluntary support policy for creativity and inventiveness, which conditions the coherent and effective evolution of the culture and knowledge in a company. To support the creative and inventive processes of the company, there are some basic hypotheses to consider.

The first hypothesis, as we saw in the previous sections, is that the creative process is rooted in the existing knowledge capital of the company. This is a hypothesis that is contrary to certain beliefs ("it's better to forget what you know to be more innovative") and several practices (do not waste your time analyzing the past and/or what already exists to find new ideas) that are more associated with "spontaneous generation" than evolutionary hypotheses.

A second hypothesis that reinforces the first one is called "path dependency" in economics, for which innovation is a process of "endogenous and cumulative technological creation". In other words, it is the very nature of the accumulated knowledge capital in an organization that predetermines the evolutionary path of this knowledge (even of the organization itself). There is neither pure creation nor creation dictated by only external constraints, but the evolution of ideas within a company through assimilation, accommodation, mutation, etc. Therefore, existing knowledge conditions future knowledge and leads to innovation. This is what was shown previously about the use of knowledge drilling techniques.

Through these strong hypotheses, we can determine the innovation success factors in a company and thereby be able to make an evaluation and progress operations in this domain.

The French KM Club constructed an assessment grid called the Innovation Maturity Model (IMM) that provides an image of the company in its capacity to generate innovation and makes it possible to make recommendations to improve that capacity. This grid includes around twenty-five criteria, grouped into four classes: processes, laws of innovation, organization, and cultural factors (Figure 9.18 and Table 9.2):

– The policies are the KM processes that contribute to the evolution of the organization's knowledge capital, and therefore to innovation, and which make it possible to identify maturity criteria (capacity for surprise, capacity for integrating external knowledge, etc.).

– Innovation laws are general tendencies that guide the evolution of knowledge, in the same way as biological evolution laws. Some laws identified in case studies have made it possible to define maturity criteria (capacity for assimilation, accommodation, saturation, disruption, etc.).

– Organizational aspects are numerous and diverse and provide the greatest number of criteria: the organization of R&D, cooperation, competence management, patent management, etc.

– Psychosocial aspects are effectively strong indicators of a company's capacity to innovate: the management of atypical situations, constraints, personal and collective initiatives, etc.

Major topics	Criteria
Policies for innovation	1. Capacity for inquiry 2. Capacity to integrate external knowledge 3. R&D policy 4. Policy regarding patents and/or publications 5. Cooperation policy 6. Policy for managing professional paths
Organization and facilitation of innovation	7. Search for heterogeneity of people within the company 8. Capacity to combine key competences in relation to innovative projects 9. Impact of the organizational structure of the company on innovation 10. Capacity to generate freedom 11. Specific organization of creativity supervision
Attitudes favoring innovation	12. Capacity for assimilation 13. Capacity for accommodation 14. Capacity to manage breakthroughs 15. Capacity to exceed performances 16. Capacity to manage atypical situations

Cultural factors	17. Management of restrictions 18. Capacity to challenge the status quo 19. Presence of a company culture turned toward innovation 20. Capacity of the company to encourage the creation of ideas and innovative projects 21. Developing personal and collective attitudes encouraging innovation

Table 9.2. *Grid of IMM criteria*

TOPIC ORGANIZATION AND FACILITATION OF INNOVATION

Criterion 11 Specific organization of creativity

Are there specific processes in place to facilitate creativity?

Level 1 No specific organization for supervising creativity

The need is not recognized because we think that creativity is “natural” or that it is not useful.

Level 2 Sporadic support for creativity processes

It is not part of the culture to support creativity, but when a need is identified in creativity seminars, creativity groups are organized

Level 3 Restricted organization of creativity supervision

This organization is restricted to a dedicated entity

Level 4 Systematic recourse to creativity

This recourse is made regardless of the subject; the creativity support process is generalized to the whole organization or the whole company to encourage the emergence of innovative ideas

Figure 9.18. *Example of IMM criteria*

9.7. Conclusion

KM processes are numerous and diverse, whether they consist of the organization of knowledge resources, knowledge codification, knowledge sharing, knowledge search, or knowledge creation. Many processes are already in place in companies, which have fortunately not waited until we started talking about KM to practice it in an implicit way.

The goal of a strategic KM plan is to align all these processes based on the objectives reflected and shared in the company. For some processes, this requires coordination with other services in the company (information systems, documentation, scanning, innovation, etc.). For other processes, this requires redefining or repositioning them (writing documents, experience feedback, etc.), or even defining new and innovative tasks (such as knowledge engineering for knowledge books, knowledge communities, knowledge maps, expertise management, etc.).

A successful KM plan is a system that ends up integrating into the daily practice of the company. To do this, it must be a reflection of the company's knowledge capital: collaborators must be able to access the information that is useful to them for their activities, knowledge must be able to be shared simply and freely between actors, it must be capitalized on in order not to be lost, and it must be updated and renewed systematically based on the environment and the production objectives of the company.

KM processes must be the focus of the company's management and rely on the active engagement of all collaborators. This is how a company can transform itself into a true knowledge-based organization, capable of responding to the requirements of the new economy as well as the new challenges of society.

Bibliography

[ADA 00] ADAMIC L.A., HUBERMAN B.A., BARABÁSI A.L. *et al.*, "Power law distribution of the world wide web", *Science*, vol. 287, no. 5461, 2000.

[AFN 15] AFNOR, ISO/FDIS 9001, International Organization for Standardization, available at: http://groupe.afnor.org/produits-editions/bivi/FDIS%20ISO%209001E.pdf, 2015.

[ALB 02] ALBERT R., BARABÁSI A.L., "Statistical mechanics of complex networks", *Review of modern physics*, vol. 74, pp. 47–97, 2002.

[ALT 84] ALTSHULLER G.S., *Creativity as an Exact Science: The Theory of the Solution of Inventive Problems*, Gordon and Breach Science Publishing, New York, 1984.

[ARG 99] ARGYRIS C., *On Organizational Learning*, 2nd Ed., Blackwell Publishing, Oxford, 1999.

[AVE 10] AVERSON P., "*The Balanced Scorecard and Knowledge Management*", Balance Scorecard Institute, 2010.

[BAR 03] BARABASI A.L., BONABEAU E., "Scale-Free Networks", *Scientific American*, vol. 288, no. 5, 2003.

[BER 68] BERTALLANFFY L., *General System Ttheory*, Georges Braziller, New York, 1968.

[BIE 00] BIERLY P.E., KESSLER E.H., CHRISTENSEN E.W., "Organizational Learning, Knowledge and Wisdom", *Journal of Organizational Change Management*, vol. 13, no. 6, pp. 595–518, 2000.

[BOU 93] BOUGNOUX D., *Sciences de l'information et de la communication*, Larousse, Paris, 1993.

Knowledge Management: The Creative Loop, First Edition. Jean-Louis Ermine.

[BRU 08] BRUNEL S., *Ingenition,* Éditions Universitaires Européennes, 2008.

[CAP 08] CAPLAT G., *Modèles et métamodèles*, Collection sciences appliquées, Presses Polytechniques Université Romande, Insa Lyon, 2008.

[CAR 04] CARLUCCI D., MARR B., SCHIUMA G., "The knowledge value chain: how intellectual capital impacts on business performance", *Int. J. Technology Management*, vol. 27, no. 6/7, pp. 575–590, 2004.

[CHEN 03] CHEN C., *Mapping Scientific Frontiers: The Quest for Knowledge Visualization*, Springer, 2003.

[CHI 82] CHISHOLM R., "*Knowledge as Justified True Belief*", *The Foundations of Knowing*, University of Minnesota Press, Minneapolis, 1982.

[CHO 00] CHONG C.W., HOLDEN T., WILHELMIJ P. *et al.*, "Where does knowledge management add value?", *Journal of Intellectual Capital*, vol. 1, no. 4, pp. 366–380, 2000.

[CHO 06] CHOO C.W., *The Knowing Organization: How Organizations Use Information to Construct Meaning, Create Knowledge, and Make Decisions*, Oxford University Press, Oxford, 2006.

[CLU 17] CLUB GESTION DES CONNAISSANCES, Knowledge Handbook and Knowledge Workbook, 2017.

[COH 06] COHENDET P., CREPLET F., DUPOUËT O., *La gestion des connaissances, firmes et communautés de savoir*, Economica, Paris, 2006.

[COH 14] COHENDET P., "Les communautés de connaissance", Projet BourbaKeM, http://www.agecso.com/wp/bourbakem/, no. 6, 2014.

[COH 90] COHEN W.M., LEVINTHAL D.A., "Absorptive Capacity: a New Perspective on Learning and Innovation", *Administrative Science Quarterly*, vol. 35, pp. 128–152, 1990.

[DAV 98] DAVENPORT T.H., PRUSAK L., *Working Knowledge: How Organizations Manage What They Know*, Harvard Business School Press, Boston, 1998.

[DEF 85] DEFORGE Y., *Technologie et génétique de l'objet industriel*, Éditions Maloine, Paris, 1985.

[DRU 59] DRUCKER P., *Landmarks of Tomorrow*, Harper and Brothers, New York, 1959.

[DRU 93] DRUCKER P., *Post-Capitalist Society*, Butterworth Heinemann, Oxford, 1993.

[ECO 72] ECO U., *La structure absente, Introduction à la recherche sémiotique*, Mercure de France, Paris, 1972.

[ECO 76] ECO U., *A Theory of Semiotics*, Macmillan, London, 1976.

[ECO 88] ECO U., *Le signe*, Collection Média, Éditions Labor, Paris, 1988.

[ERM 00] ERMINE J.-L., *Les systèmes de connaissances*, Hermès Science, 2nd ed., Paris, 2000.

[ERM 03] ERMINE J.-L., *La gestion des connaissances*, Hermès Science Lavoisier, Paris, 2003.

[ERM 05] ERMINE J.-L., "A Theoretical and formal model for Knowledge Management Systems", *Proceedings of ICICKM'2005* (2nd International Conference on Intellectual Capital and Knowledge Management), pp. 187–199, Dubai, 21-22, November 2005.

[ERM 07] ERMINE J.-L., LEBLANC B., "A Shannon's Theory for Knowledge", in HAWAMDEH S. (ed.), *Creating Collaborative Advantage through Knowledge and Innovation*, World Scientific Publishing Company Pte Ltd, 2007.

[ERM 08] ERMINE J.-L., *Management et ingénierie des connaissances, modèles et méthodes*, Hermès Science Lavoisier, Paris, 2008.

[ERM 12] ERMINE J.-L., MORADI M., BRUNEL S., "Une chaîne de valeur de la connaissance", *Management International*, vol. 16, pp. 29–40, 2012.

[EUS 03] EUSTACE C., "A new perspective on the knowledge value chain", *Journal of Intellectual Capital*, vol. 4, no. 4, pp. 588–596, 2003.

[FLO 10] FLORIDI L., *Information – A Very Short Introduction*, Oxford University Press, Oxford, 2010.

[FOR 09] FORAY D., *L'économie de la connaissance*, Éditions La Découverte, Collection Repères 320, Paris, 2009.

[GAU 04] GAUME B., "Balades aléatoires dans les Petits Mondes lexicaux", *Information, Interaction, Intelligence*, vol. 4, 2004.

[GRA 91] GRANT R.M., "The resource-based view of competitive advantage: implications for strategy formulation", *California Management Journal*, vol. 33, Spring, pp. 14–134, 1991.

[GRA 96] GRANT R.M., "Toward a Knowledge-Based Theory of the Firm", *Strategic Management Journal*, vol. 17, Winter Special Issue, pp. 109–122, 1996.

[GRO 15] DE GROSBOIS J., Nuclear Knowledge Management (NKM), IAEA, available at: https://www.iaea.org/nuclearenergy/nuclearknowledge/about-nkm.html, 2015.

[GUR 69] GUREVICH B.M., "Topological entropy of enumerable Markov chains" (Russian), *Dokl. Akad. Nauk SSSR*, vol. 187, pp. 715–718, 1969, (English translation) *Soviet Math. Dokl*, vol. 10, no. 4, pp. 911–915, 1969.

[HAL 93] HALL R., "A framework linking intangible resources and capabilities to sustainable competitive advantage", *Strategic Management Journal*, vol. 14, pp. 607–618, 1993.

[HAY 00] HAYES B., "Graph Theory in Practice", *American Scientist*, vol. 88, no. 1, pp. 9–13, 2000.

[HOL 01] HOLSAPPLE C.W., SINGHB M., "The knowledge chain model: activities for competitiveness", *Expert Systems with Applications*, vol. 20, pp. 77–98, 2001.

[HUB 91] HUBER G.P., "Organizational Learning: an Examination of the Contributing Processes and the Literatures", *Organization Science*, vol. 2, pp. 88–115, 1991.

[JAS 05] JASHAPARA A., "*Knowledge Management: an Integrated Approach*", FT Prentice Hall, Harlow, 2005.

[KAP 04] KAPLAN R.S., NORTON D.P., "*Strategy Maps: concerting intangible assets into tangible outcomes*", Harvard Business School Press, Brighton MA, 2004.

[KLE 02] KLEINFELD J.S., "Could it be a big world after all? The Six Degrees of Separation Myth", *Society*, vol. 39, no. 61, 2002.

[KOG 92] KOGUT B., ZANDER U., "Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology", *Organization Science*, vol. 3, pp. 383–397, 1992.

[LAV 91a] LAVE J., "Situating learning in communities of practice", in RESNICK Lauren B., LEVINE John M., TEASLEY Stephanie D. (eds), *Perspectives on socially shared cognition*, American Psychological Association, Washington D.C., 1991.

[LAV 91b] LAVE J., WENGER E., *Situated learning, – Legitimate peripheral participation*, Cambridge University Press, Cambridge, 1991.

[LAZ 00] LAZARIC N., "The role of routines, rules and habits in collective learning: some epistemological and ontological considerations", *European Journal of Economic and Social Systems*, vol. 14, no. 2, 2000.

[LEE 00] LEE C.C., YANG J., "Knowledge value chain", *Journal of Management Development*, vol. 19, no. 9, pp. 783–794, 2000.

[LEB 07] LE BIHAN F., DELADRIERE J.-L., MONGIN P. *et al.*, *Organisez vos idées avec le mind mapping*, Dunod, Paris, 2007.

[LEM 77] LE MOIGNE J.-L., *La théorie du Système Général*, *théorie de la modélisation*, PUF, Paris, 1977, and 3rd ed., 1990.

[LEM 90] LE MOIGNE J.-L., *La modélisation des systèmes complexes*, Dunod, Paris, 1990.

[LEO 95] LEONARD-BARTON D., *Wellsprings of Knowledge*, Harvard Business School Press, Boston MA, 1995.

[LEV 69] LEVI-STRAUSS C., *Mythologiques*, University of Chicago Press, Chicago, 1969.

[MAT 17] MATTA N., "L'ingénierie des connaissances", Projet BourbaKeM, http://www.agecso.com/wp/bourbakem/, no. 12, 2017.

[MIL 67] MILGRAM S., "The small world problem", *Psychol. Today*, vol. 1, pp. 60–67, 1967.

[MOL 75] MOLES A., Preface to "Théorie mathématique de la communication" by C. SHANNON, W. WEAVER, Retz-CEPL, Paris, 1975.

[MOR 08] MORADI M., BRUNEL S., VALLESPIR B, "Value Chain Approach to Semantic Process of Knowledge Creation: a Perspective from Data to Capability", *29th McMaster World Congress*, Hamilton, Canada, 16–18 January 2008.

[MOR 09] MORADI M., Enterprise Modeling and Knowledge Management: toward a unified enterprise knowledge modeling, PhD thesis, University of Bordeaux 1, 2009.

[MOR 86] MORIN E., *La méthode, 3. La connaissance de la connaissance*, Éditions du Seuil, Paris, 1986.

[MOR 90] MORIN E., *Introduction à la pensée complexe, Communication et complexité*, ESF, Paris, 1990.

[MPH 94] M'PHERSON P., "Accounting for the value of information", *Aslib Proceeding*, vol. 46, no. 9, September, 1994.

[NEL 82] NELSON R., WINTER S. G., *An Evolutionary Theory of Economic Change*, Belknap Press of Harvard University Press, Cambridge, 1982.

[NEL 91] NELSON R., "Why do firms differ and how does it matter?", *Strategic Management Journal*, vol. 12, pp. 61–74, 1991.

[NON 95] NONAKA I., TAKEUCHI H., *The Knowledge-Creating Company*, Oxford University Press, Oxford, 1995.

[PED 97] PEDLER M., BURGOGYNE J., *The Learning Company: A strategy for sustainable development*, 2nd ed., McGraw-Hill, London, 1997.

[PEI 34] PEIRCE C. S., *Collected papers: Volume V. Pragmatism and pragmaticism*, Harvard University Press, Cambridge MA, 1934.

[POR 85] PORTER M., *Competitive Advantage: Creating and Sustaining Superior Performance*, Free Press, New York, 1985.

[POW 01] POWELL T., "The Knowledge Value Chain (KVC): how to fix it when it breaks", in WILLIAMS M.E. (ed.), *22nd National Online Meeting*, Information Today, Medford NJ, 2001.

[PRA 90] PRAHALAD C.K., HAMEL G., "The core competence of the corporation", *Harvard Business Review*, vol. 68, no. 3, pp. 79–91, 1990.

[QUI 92] QUINN J.B., *Intelligent Enterprise: A Knowledge and Service Based Paradigm for Industry*, Free Press, New York, 1992.

[ROS 79] DE ROSNAY J., *The Macroscope*, Harper & Row, New York, 1979.

[ROT 96] ROTH A.V, "Achieving Strategic Agility through Economies of Knowledge", *Strategy and Leadership*, vol. 24, pp. 30–37, 1996.

[ROW 07] ROWLEY J., "The wisdom hierarchy: representations of the DIKW hierarchy", *Journal of Information Science,* vol. 33, no. 2, pp. 163–180, 2007.

[RUE 01] RUETTE S., Chaos en dynamique topologique, en particulier sur l'intervalle, mesures d'entropie maximale, PhD thesis, Aix-Marseille University 2, Faculté des Sciences de Luminy, November 2001.

[SAU 12] SAULAIS P., ERMINE J-L., "Creativity and Knowledge Management", *The Journal of Information and Knowledge Management Systems*, vol. 42, no. 3/4, 2012.

[SHA 48] SHANNON C.E., "A Mathematical Theory of Communication", *The Bell System Technical Journal*, vol. 27, pp. 379–423, 623–656, July, October, 1948.

[SHA 49] SHANNON C.E., WEAVER W, *The Mathematical Theory of Information*, University of Illinois Press, Urbana, 1949.

[SHA 98] SHANNON C., WEAVER W., *The Mathematical Theory of Communication*, University of Illinois Press, Urbana, 1998.

[SIM 58] SIMON H., MARCH J.G., *Organizations*, Wiley, New York, 1958.

[SIM 95] SIMONYI G., "Graph entropy, a survey, Combinatorial Optimization", *DIMACS, Series in Discrete Mathematics and Theoretical Computer Science*, vol. 20, pp. 399–441, 1995.

[SPE 96] SPENDER J.C., “Making Knowledge the Basis of a Dynamic Theory of the Firm”, *Strategic Management Journal*, vol. 17, Winter Special Issue, pp. 45–62, 1996.

[SPE 99] SPEEL PH., SHADBOLT N., DE VRIES W. *et al*., “Knowledge Mapping for industrial purpose”, *Conference KAW99*, Banff, Canada, 1999.

[STA 92] STALK G., EVANS P., SHULMAN L.E., “Competing on capabilities: the new rule of corporate strategy”, *Harvard Business Review*, March–April, pp. 57–69, 1992.

[SVE 01] SVEIBY K.E., “A knowledge based theory of the firm to guide strategy formulation”, *Journal of Intellectual Capital*, vol. 2, no. 4, pp. 344–358, 2001.

[TEE 97] TEECE D.J., PISANO G., SHUEN A., “Dynamic Capabilities and Strategic Management”, *Strategic Management Journal*, vol. 18, no. 7, pp. 509–533, 1997.

[THO 14] THOMAS C., “La codification des connaissances organisationnelles”, Projet BourbaKeM, http://www.agecso.com/wp/bourbakem/, no. 7, 2014.

[TOU 88] TOUSSAINT SAMAT M., *La Cuisine de Maguelonne : ma méthode, mes recettes, mes secrets*, Éditions Bordas, Paris, 1988.

[WAN 05] WANG C.L., AHMED P.K., “The knowledge value chain: a pragmatic knowledge implementation network”, *Handbook of Business Strategy*, vol. 6, no. 1, pp. 321–326, 2005.

[WAT 98] WATTS D.J., STROGATZ S.H, “Collective dynamics of ‘small – world’ networks”, *Nature*, vol. 393, pp. 440– 442, 1998.

[WEN 98] WENGER E., *Communities of Practice: Learning, Meaning and Identity*, Cambridge University Press, New York, 1998.

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