HAL open science

Methods and tools for Knowledge Management in research centres

Jean-Louis Ermine

To cite this version:

Jean-Louis Ermine. Methods and tools for Knowledge Management in research centres. EJKM : Electronic journal of knowledge management, 2010, 8 (3), pp.293-306. hal-00524417

HAL Id: hal-00524417

https://hal.science/hal-00524417v1

Submitted on 7 Oct 2010

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Methods and Tools for Knowledge Management in Research Centres

Jean-Louis ERMINE
Professor
TELECOM Business School, Évry, France

Jean-Louis Ermine

Telecom Business School

9 Rue Charles Fourier

91011 Evry Cedex, France

jean-louis.ermine@it-sudparis.eu

+33 (0)1 60 76 45 77

Jean-Louis Ermine obtained a PhD in fundamental mathematics from the University Denis Diderot, Paris in 1976, and the title of National Research Director in computer science in 1990 at the University of Bordeaux.

For more than ten years, at the University of Algiers, then Bordeaux, he carried out research in mathematics, on algebraic geometry applied to functions of several complex variables. In 1985, he switched to Artificial Intelligence. In 1991, he joined the French Atomic Energy Commission (CEA) in Saclay, near Paris, where he was responsible for a post-graduate diploma in computer science, in collaboration with Paris-Sud University (Orsay). From 1994 to 2000 he was responsible for the Knowledge Management Group in the CEA. In 2003, he joined the Business School of the French "Institut Télécom" as head of the Information Systems Department, to develop research and teaching activities in Knowledge Management. He is now Associate Dean for Research in this school.

Jean-Louis Ermine is the inventor of the MASK method, a Knowledge Management methodology used in the CEA and in a great number of French and foreign companies since 1993. He has written more than 100 scientific articles and four books on Knowledge Management and Engineering, and has supervised 22 PhDs in these domains. He was named as "CEA senior expert" in 1996, and "CEA expert consultant" for external companies in 1997. Since 2002, he has acted as a KM expert at the United Nations (International Atomic Energy Agency, International Telecommunications Union). In 1999, he founded the French Knowledge Management Club, an association grouping a large number of French speaking companies. He is now the president of this club. Since 2006 he has been the invited researcher at the « Centre d'Études Francophones pour l'Informatisation des Organisations » (CEFRIO) in Canada. In 2007 he was named by the French government as KM expert for the UN/IAEA.

Jean-Louis Ermine has been project leader or advisor in numerous research or industrial KM projects in public or private companies in France (Industry, Energy, Transport, Defence, Banking, SMEs etc.) and abroad (Sonatrach (Algeria), Hydro-Québec, Public Administration (Canada), Nuclear Research Centre (Brazil), National Nuclear Safety Authorities (IAEA Asia) etc.

Methods and Tools for Knowledge Management in Research Centres

Abstract: In the Knowledge Based Economy, research centres, whether industrial or public, play a fundamental role. In terms of Knowledge Management, these organisations have a special status, because their production is knowledge and only knowledge. The Knowledge Capital they accumulate in their activities therefore is a strong strategic issue and the management of these assets has become crucial. The problem addressed in this paper is to design a pertinent methodology for Knowledge Management considering the specificity of knowledge production by research centres. This methodology is based on a suitable model to describe that knowledge production.
The reference model is built on knowledge flows between the organisation and its knowledge workers, and a subsystem called "Knowledge Capital". A research centre is defined by the fact that its product is only knowledge and is accumulated in its knowledge subsystem. Some economical characteristics of this Knowledge Capital are shown as being very adapted to knowledge produced in research centres.
The methodology is based on two tools. The first tool is the knowledge map that can represent a comprehensive model of the Knowledge Capital of the organisation, which is often not well known or unstructured. That map is built on a shared and consensual vision of the main knowledge actors. It is not a map produced by a knowledge tool, but a co-construction (through interviews) with the knowledge actors. The second tool is a grid for criticality analysis (Critical Knowledge Factors), which evaluates the knowledge domains of the organisation and suggests appropriate actions to put in place for the most critical domains. This tool is a guide for interviewing knowledgeable actors in the organisation, to collect and analyse a set of data for decision support. The aim of the methodology is to provide a set of recommendations to build a KM plan of actions to preserve, share and make evolve the Knowledge Capital.
The methodology has been elaborated through constant feed-back with practice, and has been validated in many real cases in various countries. Three case studies (France, Brazil, and Canada) are succinctly described to exemplify the effectiveness of the methodology.

Keywords: knowledge management, knowledge capital, research centre, knowledge map, critical knowledge factors,

1. Introduction

In the so-called "Knowledge Based Economy", the role of research centres, private or public, is becoming predominant (OECD 2000, OECD 2004). They are crucial for the production of knowledge, which is an economic asset capable of sustainable growth and a decisive competitive advantage for businesses. For example, the objective of the Lisbon process, launched in 2000 by the European Council, clearly defines the framework for this community of nations: *making in Europe the most dynamic and competitive knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion, and respect for the environment by 2010" (Europe 2000).*

The challenge is, first of all, macro-economic: nations, like companies or organisations, must invest heavily in research and innovation. Such investments in "knowledge" are increasing sharply in the world. Moreover, this interest in knowledge and innovation greatly impacts research centres, which are particularly involved in the knowledge economy, whether private

or public. These organisations have the characteristic of having knowledge as a core asset and as their only product. In the Knowledge Economy context, they must manage their production as a strategic asset. They therefore are in the situation where the management of their knowledge capital is the key factor of their successful integration into their socio-economic environment.

Knowledge Management in a research centre poses specific problems, which are related to the nature of knowledge, whether public or private. In this paper we propose a theoretical reference model, specific to the production of knowledge in a research centre; and we develop tools for modelling and assessment, in order to supervise and manage the production of knowledge. The proposed method is now sound and validated (Ermine 2008), and is currently being deployed in numerous organisations in different countries. We illustrate the approach developed by various case studies, in France, Brazil and Canada.

2. A reference model for knowledge management in a research centre

Knowledge Management in research centres

Research activities and Knowledge management are often linked in an information management perspective, for research communities (Gaines, Shaw 1997, Oliveira et al. 2505) or for research project (Barthes, Tacla 2002). Knowledge Management in research centres is seen as a productivity tool for knowledge creation or innovation (Hasan et al. 2006, Armbrecht et al. 2001, Suh, Sohn and Kwak 2004), general studies are made to discover the impact of Knowledge Management in R&D centres (Davis 2001, Frederiksen 2004). Except the numerous studies of implementation of technical information systems, there is a consensus on the impact of Knowledge Management in research centres on “critical factors enabling knowledge flow, with choice of IT tools of secondary importance” (Armbrecht et al. 2001).

Knowledge flows usually are not identified as such, there are often seen as information flows. Models dedicated to KM for research activities are linked to production processes, or innovation process or information sharing. Knowledge is not seen as an asset, and the status of knowledge flows are not clear. We propose a simple (even if restrictive) model to specify the knowledge flows, and how they participate in creating a new asset.

The Knowledge centre as knowledge processor

The proposed model is based on the principle that a research centre has a "knowledge reservoir" of its own. This knowledge base is much more than the sum of individual knowledge of employees, and it is capitalised, more or less over time, through information products (documents, databases, software etc.) or by knowledge exchanges/transfers, individual or collective. The knowledge is created by the research actors (which are the principal “knowledge workers” of a research centres), most of time by in interaction with the various information systems available in the centre (databases, search engines, document management systems, software etc.), some knowledge is exchanged in an informal or semi-formal way (discussions, communities, seminars etc.), it produces tacit knowledge. Some knowledge is codified in new records (publications, reports, documents etc.), it is explicit knowledge. It accumulates in the firm during its history, and forms what is called a "Knowledge Capital”.

The existence of this capital, as an intangible sub-system of the company, is still controversial, because it represents a radical alternative to the conventional view that usually equates it to processing information system for Knowledge Workers. There is then a confusion between Knowledge Capital and Information Capital.

This vision of the organisation as a "knowledge processor" can be represented by the systemic pattern of Figure 1. In this model we don't visualise yet the inputs and outputs of knowledge production as in a classical production model.

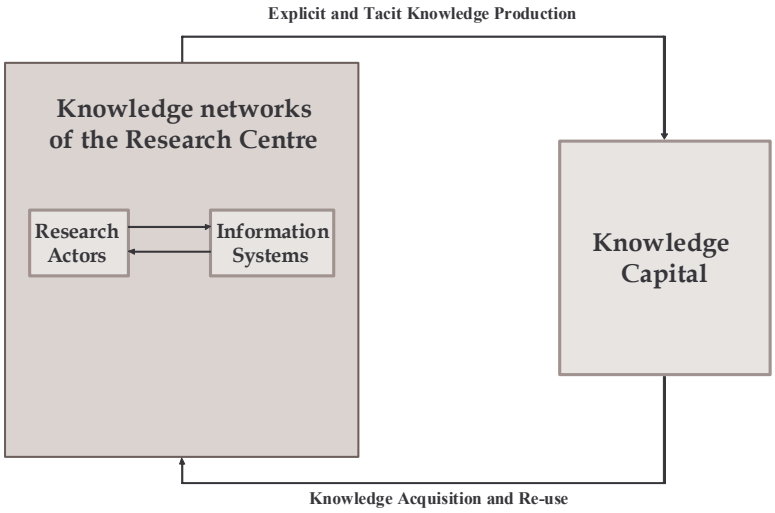

Figure 1: Research centre as a processor of knowledge flows

The interest of this model is in being able to visualise the knowledge flows, which are a specific production of the organisation, but not represented as such in conventional models. The Knowledge Capital appears as a "reservoir" which accumulates this knowledge. This sub-system is clearly an active system. This classically results in flows that create interactions with other sub-systems of the system. We have seen that these flows can be classified into two categories. The first one links the other organisation's sub-systems to the knowledge sub-system, and corresponds to the enrichment (over time) of the Knowledge Capital of the firm, through its various human actors and information systems. The second one is composed of the flows in the opposite direction corresponding to the appropriation of this knowledge to create new knowledge.

The detailed model, and the mathematical formalism can be seen in (Ermine 2005) and (Ermine 2008).

In the following we discuss the specific nature of the Knowledge Capital in research centres.

The nature of knowledge in a research centre

Knowledge management poses new problems that have been raised by this new discipline called the "Knowledge Economics" (Foray 2004). Knowledge is indeed a very strange thing. It has three basic properties, like an economic good:

• Knowledge is a good which is very difficult to control and which generates "externalities". This means that a company has much more difficulty controlling its knowledge than its machines. Two fundamental risks exist (Cohendet et al. 2006): "spill-over", which is the inadvertent disclosure of knowledge, and, conversely, "lock-in", which is an exclusive knowledge-sharing relationship, which prevents people from accessing external knowledge. Spill-over is constant, knowledge is always escaping from a firm (for instance in the market, inside the products). Such knowledge may benefit competitors, and gives nothing in return. This is called "positive externalities" (unlike patents, for example).

• Knowledge is what one calls a non-rival good. Unlike tangible goods, knowledge as a resource is inexhaustible, because it is not destroyed by use. Agents who use the same knowledge are therefore "non-rivals". An agent can use knowledge an unlimited number of times, so an unlimited number of agents may use the same knowledge. Transmitting knowledge is a positive sum game: it merely increases the number of holders.

• Knowledge is a cumulative good. Knowledge is the key element that helps create new knowledge. Knowledge accumulates and therefore this accumulation is a factor of collective progress for the stakeholders.

These properties, which can be negative aspects in a firm, are positive features in a research centre, especially the public ones: "lock-in" is usually not deontological, and "spill-over" is encouraged, the non-rival character of knowledge is driving the research, the accumulation of knowledge is the current priority of the research activity. We notice that this could lead to paradox, in the case of a private research centre, that needs to protect the produced knowledge. It is a common "necessary contradiction", that is not always obvious to manage.

In a firm, centred on its production process (of goods or services), knowledge is, in economic language, a "joint product". The production of knowledge in business occurs "accidentally", as a side effect, while the relevant community is oriented towards other goals. Knowledge and know-how in the company are produced "unintentionally". This is a complex process related to learning, including learning by doing. This process, as we have already said, is cumulative: the knowledge cannot be seen as a volatile flow (as it often was), but as a capital accumulating in the organisation. Thus, while fulfilling the production tasks, the firm produces jointly, an unintended (or even free!) new wealth that accumulates in the organisation. There are a lot of questions about this new wealth, because currently it is unclear how this wealth is reinvested in the productive loop.

In the framework of a research centre, this assumption is unfounded. The basic production of such an organisation is knowledge itself; it is not a joint product. Its Knowledge Capital is the core asset, and the cumulative nature of knowledge makes the Knowledge Capital the basis for production of new knowledge. It therefore appears that the model given in figure 1 can be used for a research centre with the emphasis on the Knowledge Capital as a strategic element. It is the main asset of the organisation and not a joint asset.

In the following we propose a specific representation of the Knowledge Capital, in order to set up a specific asset management.

3. Knowledge mapping or cartography

If we consider that Knowledge Management is the management of a Knowledge Capital as defined and modelled in the previous §, this management poses an obvious problem. In fact, this capital is not fully visible in the organisation, it is partially so through its visible part (records of explicit knowledge, such as the publications of its researchers). Its full identification is not obvious and does not always correspond to the intuitive idea that people have. It includes in fact all components, internal or external to the organisation, involved in the constitution of the knowledge corpus concerned. The identification of these components is necessary to delineate the body of knowledge that we want to manage. In a research centre, it

would be wrong to believe that the structure of the corpus of publications, often of a "disciplinary" type, is a unique vision of this capital.

This raises the problem of representing that capital in a meaningful way, and according to various management objectives. For that purpose, there are tools and methods grouped under the term "knowledge mapping" or “knowledge maps” (Eppler 2003). According to (Speel et al. 1999), "Knowledge mapping is the set of techniques and tools used to analyze and visualize areas of knowledge, relations between these areas in order to highlight some specific features in different professional knowledge.” Knowledge maps are designed by representing some attributes of tacit or explicit knowledge in a graphic form which is easily understood by end-users (managers, experts, engineers, etc.). They help to make a careful analysis to determine, in a strategic objective, what knowledge has to be supported, developed, abandoned etc… The mapping (or cartography) becomes a tool for decision-making.

In the context of an entity dedicated to research, knowledge maps are tools that make more sense than elsewhere, since they are "structural" representations of the entity, and almost become tools to help manage the production, not only to improve performance. They play the role of business process modelling for productive organisations.

As a mapping technique, there is a famous methodology, called « Mind Mapping », created and popularised by Tony Buzan (Buzan 2003). This is the area of “Mind Maps”, sometimes called mental maps, or heuristic maps or cognitive maps. This is an approach that permits the mental representation of one or several persons concerning a specific problem to be visualised graphically. This is a tree-like representation, that is built recursively from a root node (the subject of the map), eliciting gradually, by building more and more refined branches, the different elements linked to the previous node. This is a visual and symbolic way to represent a complex problem in a “simple” manner. A cognitive map is enriched, in general, by different elements which improve its comprehension: icons, colours, graphics (images, symbols), annotations etc. that theoretically allow an easy understanding.

Our method uses principles of Mind Mapping, but in a very controlled manner. The map of knowledge domains of the concerned research centre (or a part of it) is built by analysing documents (activity reports, strategic documents …) in a first part and, in a second part, by interviewing significant people, aware of the research projects and the research organisation, identified by a “name-dropping process”. The map has a defined semantic and its own graphical symbolism. The usual software to build the map is a classical customised Mind Mapping tool like MindManager® .

Below, in the examples, we show how mapping techniques were used (e.g. Figure 3).

In the next §, this representation of the centre’s Knowledge Capital is used to perform a kind of “risk/opportunity assessment”, called criticality analysis, that can be used to build a coherent Knowledge Management plan.

4. The criticality analysis

Organisations wishing to manage their Knowledge Capital must therefore make a careful analysis to determine their strategy and what knowledge they need to keep, develop, abandon etc. Knowledge Mapping then becomes a decision-making tool (Grundstein 2000), and can become a strategic tool for managing critical knowledge in the sense of "dynamic

capabilities" of (Teece, Pisano and Shuen 1997). We show now how to use the knowledge map as a decisional tool by assessing the “criticality” of each knowledge domain of the map, to enable to decide what is the best relevant KM action regarding the criticality.

To do this, we must develop specific criteria to assess, in the knowledge map, what knowledge is most critical for the company and why. The criticality of a knowledge domain is defined as an assessment of risks/opportunities in the domain for the organisation. There may, for instance, be a risk of knowledge or expertise loss that may prove harmful, or that it may be interesting to develop a knowledge domain for some benefits for the company (productivity improvement, new market share, etc.). It is therefore necessary to define “objectively" what are the Critical Knowledge Factors (CKF) and provide a method of evaluation to identify the most critical knowledge domains in the knowledge map.

In the literature there are a lot of attempt to define sets of criteria for Knowledge Management, for different purposes:

- Key factors of success for implementing a Knowledge Management system (see for instance the studies in (Alazmia, Zairia 2003) or (Wong, Aspinwall 2005)
- Sets of qualitative parameters designed to evaluate the performance of an organisation’s knowledge assets. There seems to have now a growing consensus around the seminal approaches by (Sveiby, 1997), (Edvinsson, Malone, 1997), (Norton, Kaplan, 1996), cf. (Bontis 2001)
- Sets of criteria to qualify a Knowledge Based System (O’Hara et al, 2000)
- Sets of criteria for knowledge strategic analysis (Bohn 1994), (Tiwana 2000)

Those criteria are not dedicated to Knowledge criticality assessment as we are interested in. They have to be modified, and there is a necessity to add new criteria to address all the facets of Knowledge Criticality. We propose a set of criteria that has been designed in a workgroup grouping a lot of companies of all kinds (small, multinational, public and private research centres, many sectors …) during nearly one year, and have been tested in some of those organisations (cf. Figure 4). To address the specific nature of Knowledge in research centres, those criteria have been adapted. They are briefly described in the following.

The Critical Knowledge Factors (CKF)

The CKF are not necessarily easy to develop. The CKF which determine the strategic importance of a knowledge corpus can be diverse, and highly dependent on the culture and business situation. One can also try to be more or less relevant or comprehensive in the development of CKF according to the importance of the KM project. Generally, there are two kinds of CKF:

- The factual criteria:

They assess the nature of knowledge, regardless of a priori knowledge of the content. These factors are intuitive, now fairly standard, and can qualify knowledge .They are classified into two classes: one evaluates the degree of expertise of the knowledge, the other assesses the rarity and fragility of the knowledge.

Examples of such factors, characteristic for knowledge in research centres:

- The depth: non expert, technical, specialized, expert
- The width: specific, multidisciplinary, transdisciplinary, generalized
- The complexity: complicated, simple complexity, complexity, high complexity

- The strategic criteria:

They are unavoidable in a criticality study. They describe the adequacy of knowledge with respect to the missions or the strategic objectives of the organisation. Knowledge can be

complex, rare and fragile, but it may not be critical because it is not consistent with the objectives and this point must be carefully analyzed in regard to the strategy of the organisation. The strategic criteria are of course specific to each organisation. They must be prepared carefully in conjunction with executives at the highest level of the organisation.

The evaluation grid for CKF

Each CKF is intended to be evaluated. Each factor is rated on a scale with multiple levels, representing different levels of achievement. Each CKF evaluation is based on a question. Each level must be expressed by a clear and concise sentence, avoiding vagueness and confusion.

The evaluation of the criticality of a knowledge domain is assigned a score for each factor and for each knowledge domain. The more critical the domain, with respect to the factor, the higher the grade. Each domain is assessed independently with all the CKF. This may lead to a laborious implementation because of the large number of domains and criteria, and if there are many evaluators. Therefore the material used should facilitate the assessment task. The results are summarized graphically with the help of Excel Radar diagrams (also called Kiviat) (see examples below, e.g. figure 2).

Calculation of criticality of a domain

For each domain, several agents may be involved in the assessment. The principle of evaluation is that different evaluators should assign a rating to all factors. The calculation of the average evaluations facilitates the analysis of criticality on different levels (overall average, per reviewer, per factor). The calculation of the global criticality of a domain is obtained by averaging all scores. Several criteria can be combined or merged for different kinds of cross-analysis.

5. Examples

We have described a research centre as a "Knowledge Processor", which includes a "Knowledge Capital" as a subsystem per se, with specific characteristics. Knowledge Management in those organisations must take into account that point of view. For a pertinent representation of the Knowledge Capital, we propose to use "knowledge mapping" techniques derived from Mind Mapping to build, with knowledge actors, the knowledge map which is a representation of the Knowledge Capital. A risk/opportunity assessment for this Knowledge Capital to support decision is necessary, and has to consider the specific nature of knowledge in research centres. We propose to use "Critical Knowledge Factors" that are evaluated by knowledge actors in the organisation. Those two tools are useful for decision making for implementing KM processes and tools.

In that §, we give examples of implementing methodologies using the tools described above, with three essential phases:

- knowledge map construction with knowledge actors
- criticality analysis made with knowledge actors
- Decision and KM methods or tools implementation.

Those examples have been chosen for different reasons:

- There are not confidential
- They represent a representative panel of research centres in different countries
- The author of that article was deeply involved in the realisation of those projects
- There exist some available articles on those projects to get more details, if needed

- There is some variability in each case, for building the knowledge map, for designing and evaluating Critical Knowledge Factors.

National Research and Safety Institute (INRS)

The INRS (French National Institute of Research and Security) was created in 1947 with the support of the National Health Insurance Office of Workers. The INRS is a non-profit organisation. Its aim is to contribute, by all appropriate means, to the improvement of safety and hygiene in professional activities, and to prevent accidents and professional diseases. It has 625 staff on 2 sites. The KM project took place in the Research and Study Centre (450 people).

The INRS started with a pilot KM project (Matta et al. 2001). The objective of this operation was to demonstrate the value of a knowledge capitalisation methodology. The capitalisation process at the INRS led to the implementation of a "Knowledge Book". This Knowledge Book highlighted the interest of the tacit knowledge capitalisation to the INRS. The INRS wished to have a global view of relevant critical knowledge to be capitalized. A study based on knowledge mapping was then proposed in order to point out critical knowledge domains in the INRS (Aubertin 2006).

The research centre has the vocation to produce knowledge, an immaterial product. The development of the knowledge map started from a conceptual classification of domains, which organizes the information around subjects, objects or finalities. The process has several steps:

- *Location of knowledge domains*

This step consists (from reference documentation and eventually from interviews) in highlighting knowledge domains by the successive analysis of research departments, their activities, projects and products.

The necessary reference documentation consists of:

- The documents on organisation (missions, organisational charts, descriptions of activity, portfolio of activities etc.);
- Documents concerning production (publications, studies, activity statements, etc.);
- Strategic documents (mid-term plans, summaries of previous mid-term plans);
- Quality documents.

- *Construction of the representation of the Knowledge Capital by a knowledge map*

The former step is a deep analysis of the activities of the firm. The next step aims at making it accessible and more usable. The representation must be adapted to the operational vision of the people concerned. The main idea of the cartography is to distribute the different knowledge domains on strategic axes.

The definition of strategic axes is conditioned by the strategic orientation given to the business process. One may use the missions of the firm as they are defined in the basic strategy, but it may also integrate new axes concerning strategic development.

The map was built following a considerable number of discussions with different actors and numerous cross-validations. First of all, the cartography was carried out on the research domains of the institute. It was then extended to the whole portfolio of activities, including the support activities. The map is now available on the intranet with an online form, which allows employees of the institute to "self-declare" regarding a certain number of their skills.

- *Drawing up of Critical Knowledge Factors*

A set of Critical Knowledge Factors was established by taking into account the specificities of the organisation and the expectations of the cartography project. These criteria presented are organized in six families:

- Criteria concerning technical content
- Strategy criteria
- Criteria of enhancement
- Criteria of rarity
- Criteria of context
- Criteria of training

➢ *Criticality evaluation*

Every criterion must be evaluated, for each knowledge domain. For that, an evaluation scale has been established for each criterion, inspired by the evaluation methodology of the (EFQM 1999). Each criterion is given a grade from 0% to 100% representing the level of effectiveness of the criterion and each evaluation of a criterion relies on one question. Each level is expressed by a clear and synthetic sentence avoiding vague terms which may lead to confusion. The final result is displayed in a "radar" form (see figure 3). The detection of criticality has been done in an interactive way with the heads of the INRS Departments.

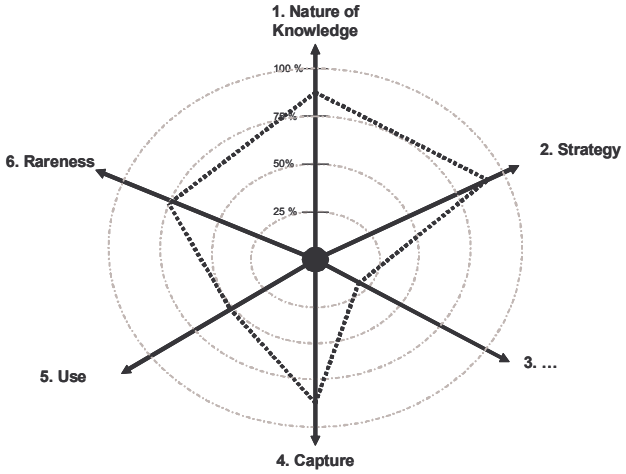

Figure 2: Criticality diagram for a knowledge domain

➢ *Conclusion*

After a first pilot project, the process Knowledge Mapping/Criticality Assessment has been deployed in the whole organisation. The KM tool chosen is a knowledge portal for the researchers of the organisation. Some of the most critical tacit knowledge has been capitalised with the "knowledge book" technique.

The knowledge map, which is now available on line in the company intranet, is now used as an interface for a "knowledge server" offering a selective access to different knowledge resources:

- The criticality analysis for decision making;
- The available documentary resources;
- The knowledge repository;
- The skills repository;
- The modelled processes mobilizing the key skills.

Instituto des Pesquisas y Nucleares (IPEN)

IPEN is a research centre of the National Centre of Nuclear Energy (CNEN: Comisao Nacional De Energia Nuclear) of Brazil.

Knowledge Management, for this organisation, is an important problem. Brazil has developed a real corporate knowledge in this domain, with long term investments, research and technological transfer. Nowadays, the nuclear field, as in other countries, is suffering from problems related to this considerable accumulation of knowledge: the risk of the evolution and the future of knowledge. Other specific characteristics of the Brazilian model add to these difficulties: the federation of different independent institutes, the risk of a "generation gap" due to a lack of hiring for ten years, the existence of knowledge pits which have not developed because of great changes in strategies and nuclear politics.

The project described below was conducted in a radiopharmacy centre at the research centre of Sao Paulo (IPEN) (Ricciardi, Barroso 2006). The role of this centre is the production and distribution of radiopharmacy products for use in nuclear medicine (diagnostic therapy).

This centre was created by the transformation of a research unit into an industrial production centre (and under certain aspects into a profit centre) certified ISO 9001/2000. Its employees are workers of the public sector, and it has a limited autonomy. This centre supplies 300 hospitals and clinics in Brazil. We have to note that the production of radioisotopes and of radiopharmaceutical products is still a monopoly of the Brazilian State, and that demand is growing 10% each year.

In the radiopharmacy centre, the project was developed in several steps:

- *Studies of processes*

This work was done within the context of ISO certification. The processes were described in a classical way using diagrams of flows linking related activities to processes.

- *Identification of enabling knowledge*

By a precise investigation close to the actors of processes, on each activity, operational knowledge has been identified as necessary and sufficient to carry out the processes in the best way: this deep analysis of the processes enabled the realization, for each process, of a table linking the processes, the activities and the knowledge (with added information on the products). The compilation of knowledge, extracted from each activity, allowed the precise identification of necessary and sufficient knowledge for the whole activity of the centre.

The completeness of this compilation is guaranteed by the fact that all the production processes have been used.

- *Construction of the knowledge map*

The compilation described above gives a non-structured set of available knowledge in the centre. This set contains a lot of knowledge domains. It is neither readable nor exploitable. Then it had to be structured in a tree-like map which integrates identified knowledge, for sure, but which structures itself according to the definition of the activity and the definition of the centre's mission. A map with seven axes, corresponding to fundamental knowledge domains, has been defined: planning, specific processes, production technology, norms and regulations, radioprotection, quality control, research and development. Each axe is split into themes which are themselves broken up into sub-themes (see the general map structure in figure 4).

- *Criticality Analysis*

First, Critical Knowledge Factors have been defined using Bohn's scale (Bohn 1994), adapted by (Tiwana 2000). Two criteria of "pertinence" (volume quality and complexity, importance regarding the strategic objectives of the organisation) and four criteria called "vulnerability" (difficulty to have or to train professionals of quality, difficulties due to the context, to the people involved or to the referential, availability in the internal or external context). A questionnaire and an interview plan were established, a targeted group of chosen people was formed, according to certain criteria, and the analysis of the entire knowledge domain was realized. The cartography and the analysis of criticality were largely validated during plenary sessions. The pertinence grade represents the content and the strategy. The vulnerability grade represents the difficulty of acquisition, the capacity of sharing and rarity.

A knowledge domain is called critical if the global grade is superior or equal to the average (the scores are 0, 1.5 and 3). About 30% of fields were estimated as critical, and the justifications were established.

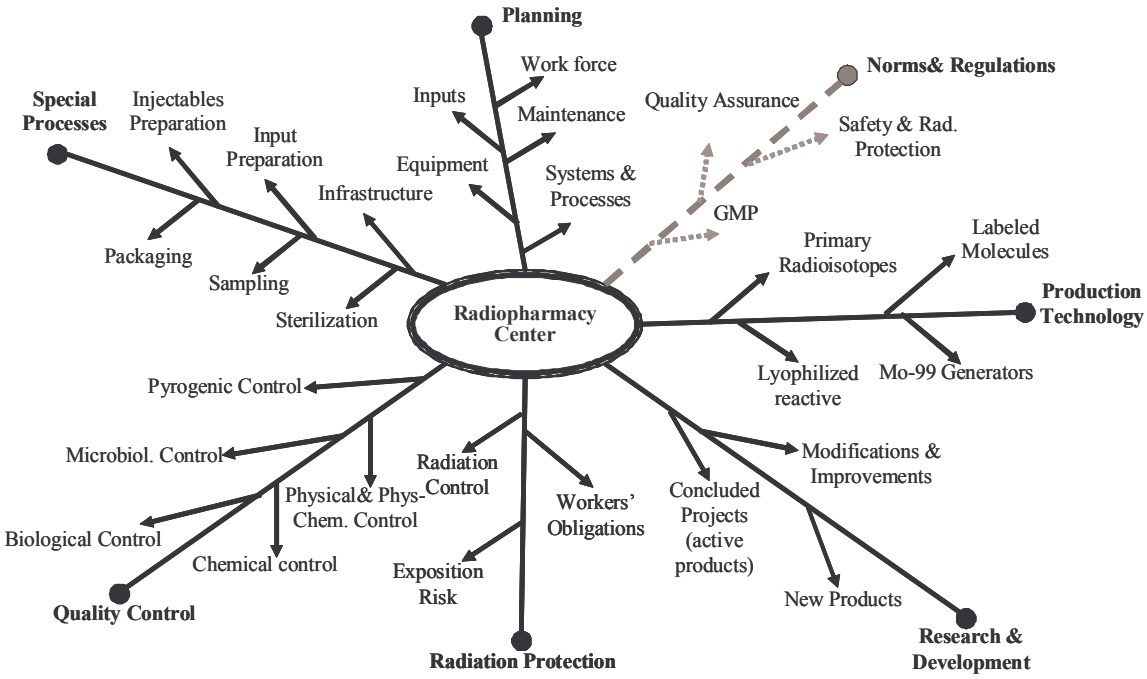

Figure 3: General View of the Knowledge Map of CR

- *Conclusion : setup of an action plan*

A set of actions which could reduce the criticality of some knowledge domains have been identified:

- A knowledge base with critical features of processes;
- A database of problems/solutions extracted from the return on experience;
- A program "RC teaching RC" (meetings and tacit transfer);
- Communities of practices;
- A program of functional development, Knowledge Management oriented;
- An organisational memory;
- A more proactive client extranet;
- A knowledge portal.

Several actions are now under way, including the design of a business portal, the design of a memory using a knowledge book methodology.

HydroQuébec Research Centre (IREQ)

HydroQuébec (Québec, Canada) is one of the biggest electricity producers and suppliers in North America. HydroQuébec is a public company and its principal shareholder is the Québec Government.

HydroQuébec has about 21,000 employees and faces difficulties linked to massive retirements and particularly the departures of the most experienced employees:

- 500 per year from 2003 to 2008
- 800 per year from 2008 to 2011

We can notice also that the « age curve » is very unbalanced.

Since the acquisition of the IREQ, the Québec Research Institute, by HydroQuébec, the firm has redefined the research activities of the institute with respect to its activity domains. Today, on the one hand, the firm is trying to improve the profitability of its projects and on the other hand, to reduce the global cost of research. In this context, IREQ started cartography of its different domains of expertise. The principal target is to rapidly identify the domains that must be reinforced, according to their respective contribution to the future development of the firm and the ageing phenomenon. Once the map of knowledge domains was drawn up, with a dozen domains, a criticality analysis was performed.

- *Collection of criticality data*

The data collection was made with over 80 interviews with the expertise leaders, innovation managers, and business unit managers. The grid of analysis is made up of 21 criteria divided into 4 thematic axes: rarity, usefulness for the firm, difficulty to capture knowledge, difficulty to operate knowledge (figure 6). Each criterion is evaluated on a scale from 1 to 4. These four levels are different descriptions aiming to define the domain studied in the most accurate way. The criteria of "rarity" and "usefulness" themes have been estimated twice: for their actual and future criticality (horizon 10 years).

Thematic axes	Criteria
Rarity	• Number and availability of possessors • Specific (non-subsidiary) character • Leadership • Originality • Confidentiality
Usefulness for the company	• Appropriateness to business operations • Creation of value for parties involved • Emergence • Adaptability • Reusability
Difficulty to capture	• Difficulty in identifying sources • Mobilization of networks • Tacit character of knowledge • Importance of tangible sources of knowledge*? • Rapidity of evolution
Difficulty to operate	• Depth • Complexity • Difficulty of appropriation • Knowledge background • Environmental dependency • Internal relational networks • External relational networks

Figure 4: Critical Knowledge Factors

- *Divergence resolution*

All the important divergences were solved by consensus. It was rather easy to obtain a grade suitable to all the evaluators.

- *Cross-analysis*

The criticality analysis allowed a strategic analysis of the institute's knowledge, thanks to cross-analysis between some criteria. This cross-analysis is represented by graphs of points, where the respective grades of each criterion are positioned. Each graph is significant for a strategic analysis:

- the graph "creation of value/pertinence" shows the promising domains ;
- the graph "usefulness to horizon 10 years/difficulty to capture knowledge" shows the domains to support ;

- the graph “rarity to horizon 10 years/difficulty to capture knowledge” shows the domain to develop with partnerships ;
- the graph “usefulness to horizon 10 years/graph rarity to horizon 10 years” gives a vision of what could be the knowledge domain of IREQ in 10 years ;

➢ *Analysis by criteria*

For each criterion, a precise analysis has detailed the possible improvement tracks. The principal axes of improvement concern the themes “difficulty to capture knowledge” and “difficulty to operate knowledge in the HydroQuébec context”.

Knowledge domains	Domains with great expertise	Domains to be valorised	very vulnerable domains	Domains that need to improve/adapt methods for training courses, knowledge transfer
1) Domain A	X	X	X	X
2) Domain B	X	X		X
3) Domain C	X		X	

Figure 5: Example of cross- analysis

➢ *Conclusion*

The criticality analysis in this project has allowed:

- the drawing up of a refined and well structured strategic vision in all the knowledge domains developed by the institute;
- these domains to be put into perspective, following the strategy of the firm;
- numerous potential actions to be identified, adding value to the whole knowledge capital of the institute: from the creation of communities of practices to capitalisation and modelling of various knowledge domains.

The project has now been generalized to the whole company (Ermine, Boughzala and Tounkara 2006)

6. Conclusion

In the Knowledge Based Economy, research centres, whether industrial or public, play a fundamental role. In terms of Knowledge Management, these organisations have a special status, because their production is only knowledge. The Knowledge Capital they accumulate in their activities therefore is a strong strategic issue. The management of these assets becomes crucial.

Our assumption is that

1) the Knowledge Capital must be considered as a whole subsystem of the organisation where the knowledge created by knowledge actors accumulates and is reused,
2) and that knowledge in research centres has specific characteristics

We can prove that assumption by building a “visible model” of that a priori previously invisible system (the Knowledge Capital): the “Knowledge Map”, and by building a specific description of the knowledge by criteria called “Critical Knowledge Factors”, in a risk/opportunity assessment objective.

Our goal is to build an operational methodology, based on those tools, providing a global approach for Knowledge Management in Research Centres. This methodology is based on three essential phases:

- knowledge map construction with knowledge actors

- criticality analysis made with knowledge actors, which evaluates the knowledge domains of the organisation and highlights the actions which are appropriate to be put into place for the most critical domains
- Decision and KM methods or tools implementation.

This approach has been validated in many real cases in various countries. Three examples of different applications of that methodology have been given in that paper.

7. References

Alazmia M., Zairia M. (2003) *Knowledge management critical success factors,* Total Quality Management & Business Excellence, Vol. 14, n°2 , pp 199-204

Armbrecht, F. M. Ross; Chapas, Richard B.; Chappelow, Cecil C.; Farris, George F.; Friga, Paul N.; Hartz, Cynthia A.; McIlvaine, M. Elizabeth; Postle, Stephen R.; Whitwell, George E. (2001) *Knowledge Management in Research And Development*, Research-Technology Management, Vol. 44, n° 4, pp. 28-48

Aubertin G. (2006). *Knowledge mapping: a strategic entry point to knowledge management*, in Boughzala I., Ermine J-L (2006). Trends in Enterprise Knowledge Management, London, Hermes Penton Science

Barthes J-P., Tacla C. A. (2002) *Agent-supported portals and knowledge management in complex R&D projects*, Computers in Industry, Vol. 48, n° 1, pp 3-16

Bohn, R. E. (1994). *Measuring and Managing Technological Knowledge*. Sloan Management Review, Fall 1994

Bontis N. (2001). *A review of the models used to measure intellectual capital*, International Journal of Management Review, Vol. 3, n° 1, pp 41-60

Buzan B. and Buzan T. (2003). *The Mind Map Book: Radiant Thinking - Major Evolution in Human Thought (Mind Set)*, London, BBC Active (3rd Revised edition)

Cohendet P., Créplet F., Dupouët O. (2006). *La gestion des connaissances, firmes et communautés de savoir*, *(Knowledge Management, firms and knowledge communities)* Paris, Economica

Davis K. (2001), *Knowledge Management for knowledgeable people. European research organisations and their knowledge management practices*, in E-work and E-commerce, Stanford B. and Chiozza (Eds.), IOS Press, pp 735-740

Edvinsson, L. and Malone, M.S. (1997) *Intellectual Capital: Realizing Your Company's True Value by Finding Its Hidden Brainpower*, New York, Harper Business

EFQM (1999). *The EFQM Excellence Model*. European Foundation for Quality Management

Eppler (2003). *Making Knowledge visible through Knowledge Maps : Concepts, Elements, Cases*, Handbook on Knowledge Management, C.W. Holsapel (ed.), Heildeberg, Springer Verlag

Ermine J-L (2005). *A Theoretical and formal model for Knowledge Management Systems*, Reading (UK), Proceedings of ICICKM'2005 Dan Remenyi ed., pp 187-199

Ermine J-L, Boughzala I. and Tounkara T. (2006) *Critical Knowledge Map as a Decision Tool for Knowledge Transfer Actions*, The Electronic Journal of Knowledge Management Volume 4 Issue 2, pp 129-140, available online at www.ejkm.com (accessed 2 November 2009)

Ermine J-L (2008). *Management et ingénierie des connaissances, modèles et méthodes, (Knowledge Management and Engineering, Models and Methods)* Paris, Hermes-Lavoisier, (Collection IC2)

Europe (2000). European Union Parliament Website *Lisbon European Council 23 and 24 March 2000 Presidency Conclusion* (http://www.europarl.europa.eu/summits/lis1_en.htm,) accessed 11th September 2009)

Foray D. (2004). *The Economics of Knowledge*, Cambridge, MIT Press

Frederiksen L. F., Hemlin S., Husted K. (2004). *The role of knowledge management in R&D: a survey of Danish R&D leaders' perceptions and beliefs*, International Journal of Technology Management, Vol. 28, n° 7-8, pp. 820 – 839

Gaines, B. R., Shaw, M. L. G. (1997) *Knowledge management for research communities*. Proc. AAAI Spring Symposium on A.I. in Knowledge Management, Stanford University, pp 55- 62

Grundstein M. (2000). *From capitalizing on Company Knowledge to Knowledge Management*, in Knowledge Management, Classic and Contemporary Works by Daryl Morey, Mark Maybury, Bhavani Thuraisingham, Cambridge, The MIT Press, pp 261-287.

Hasan, Q., Machado M., Tsukamoto M.; Umemoto K. (2006) *Knowledge creation for science and technology in academic laboratories: a pilot study*, Knowledge Management Research & Practice, Vol. 4, n° 2, pp. 162-169

Matta N., Ermine J.L., Aubertin G., Trivin J.Y. (2001) *Knowledge Capitalisation with a knowledge engineering approach: the MASK method* IJCAI'2001, Knowledge Management and Organisational memory Workshop, International Joint Conference on Artificial Intelligence, Seattle, USA, 4-10 August 2001

Norton, D. and Kaplan, R. (1996) *The Balanced Scorecard: Translating Strategy Into Action*, Boston, Harvard Business School Press

O'Hara K., Shadbolt N. and Tennison J. (2000). *Certifying KBSs: using CommonKADS to provide supporting evidence for fitness for purpose of KBSs*. In Rose Dieng and Olivier Corby (eds.) Knowledge Engineering and Knowledge Management: Methods, Models and Tools, Springer-Verlag, Berlin, 2000, pp.419-434

OECD (2000). *Knowledge Management in the Learning Society*, Paris, OECD Publications

OECD (2004). *Measuring Knowledge Management in the business sector*, Paris, OECD Publications

Oliveira J., De Souza J., Miranda R., Rodrigues S. (2005). *GCC: An Environment for Knowledge Management in Scientific Research and Higher Education Centres,* Proceedings of I-KNOW ’05, Graz, Austria, June 29 - July 1, 2005

Ricciardi R., Barroso A. (2006). *Appraising the knowledge of a radio-pharmacy centre based on processes mapping and knowledge domains cartography* in Trends in Enterprise Knowledge Management, London, Hermes Penton Science

Speel PH, Shadbolt N., De Vries W., Van Dam PH, O’hara K. (1999) *Knowledge Mapping for industrial purposes*. KAW99, October 1999, Banff, Canada

Suh W., Derick Sohn J.H., Kwak J. Yeon (2004). *Knowledge Management as enabling R&D innovation in high tech industry*, Journal of Knowledge Management, Volume 8, n°6, pp. 5-15

Sveiby, K.-E. (1997) *The New Organisational Wealth: Managing and Measuring Knowledge-Based Assets*, San Francisco, Berrett-Koehler

Teece D. J., Pisano G., Shuen A. (1997). *Dynamic Capabilities and Strategic Management Strategic Management Journal*, Vol. 18, Issue 7, pp. 509-533

Tiwana A. (2000). *The Knowledge Management Toolkit*, NJ, USA, Prentice Hall PTR

Wong K.Y., Aspinwall E. (2005) *An empirical study of the important factors for knowledge-management adoption in the SME sector*, Journal of Knowledge Management, 2005 Vol. 9 N° 3, pp 64-82