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Structured Abstract

Purpose – Providing a wide literature analysis about Knowledge Management (KM) cycle and propose one starting from a new approach: the material conservation law. Testing the KM cycle with a case study in order to understand the implications that this perspective can hold to the management of knowledge.

Design/methodology/approach – The present research adopts the descriptive case study research design. The study case approach allows to undertake an investigation that maintain the holistic and significant characteristics of the organization.

Originality/value – The new approach used to design the KM cycle is the material conservation law although the authors' consciousness that knowledge and classical resources have very different properties. The KM cycle proposed is based on nine phases and allows to understand which are the more evident phases managed inside the organization and to propose a classification of KM tools.

Practical implications – The KM cycle can be used to analyze the tools and practices adopted by the organization to manage knowledge. Enterprises could understand, from an alternative perspective, their own organization and find out strengths and weakness in the knowledge processes.

Understanding which are the most and less important KM phases for the organization could be useful to orientate a conscious management of knowledge.

Keywords – Knowledge Characteristics, Knowledge Management Cycle, Material Conservation Law, Case Study

Paper type – Academic Research Paper and Practical Paper

1 Introduction

There is a common vision that knowledge, nowadays, is a central resource for the enterprise and has assumed a fundamental role in developing organizational competitive advantage (Liebeskind, 1996; Spender, 1993; Spender, 1996). The expressions such as knowledge based theory (Havelock, 1986; Knudsen, 1995, Grant, 1996; Nickerson e Zenger, 2004) and organizational learning (Senge, 1990; Argyris, 1997; Fiol e Lyles 1985) confirm this central role in the organization. But why this importance?

Compared with traditional resources (land, labor and capital), the knowledge holds characteristics that are very different (Rullani, 2004; Spender, 1996); in particular, knowledge is (Rullani, 2004):

- multipliable, it can't be consumed;
- indivisible, the cognitive process can't be divided into time and space due to an irreversible process: from new knowledge is not possible go back to productive factors. The consequence of this characteristic is the difficult association of cost and revenues generated through the cognitive chain that create the economic value of knowledge.
- reflexive, it evolves during the time and for every application there is an evolution.

Other knowledge characteristics evidenced by Hayek (1945) are: dispersed, limited and individual. This means that knowledge is wide dispersed in people minds: thus there is the need to collect the single pieces of knowledge to completely exploit its potential.

Moreover, through the learning process, new knowledge that is generated is also involved in the continuous dynamic evolution of the knowledge dispersion. This causes even more difficulty in the riaggregation of the knowledge (Loasby, 2001).

Understanding these differences means develop new tools and new approaches for the management.

The term Knowledge Management (KM) can be defined *"an umbrella term for a wide spectrum of academic orientation"* (Alvesson and Karreman, 2001: p.996) and in this direction the authors identify three areas:

- Strategy: Bierly and Chakrabarty (1996) and Zack (1999) affirm that knowledge strategy comprises the whole strategic choices that allow organizations to create knowledge that are the basics for developing intellectual capital and to maintain competitive advantage;
- Management: related to the processes that allow the management of knowledge. Inside this area it is possible to indentify the knowledge phases (i.e. Alavi and Leidner, 1999), often linked in a knowledge management cycle (i.e. Holsapple and Joshi, 2002), and the ICT (Information and Communication Technology) tools together with managerial and organizational practices.
- Evaluation: related with the measures and techniques used to evaluate the dimensions (i.e. Stewart, 1997), the maturity (i.e. Pee et al., 2006) and the flow (i.e. Cross et al., 2002) of knowledge.

The management area and in particular the knowledge management cycle can be interpreted as a link between strategy and evaluation and seems to be the more interesting area.

For this reasons the aim of the paper is to:

1. Provide a complete classification of the knowledge management cycles developed in literature;
2. Develop an own knowledge management cycle that comes from a new approach;
3. Test the knowledge management cycle with a case studies in order to confirm the validity of the proposal and to understand managerial implications.

Therefore the research question of this work is:

- Compared to traditional management, what means managing knowledge and how can the knowledge management cycle be useful to organizations?

The paper is structured as follows: in the first part a literature analysis of the knowledge management cycles is proposed that allows to understand which are the main processes (often called phases). Successively, the authors define an own knowledge management cycle built up the material conservation law and the literature analysis developed. A single case study allows to test the knowledge management cycle proposed and evidences the KM tools adopted by the company.

2 Knowledge Management processes in literature

In the KM area the processes assume an important role (i.e. Boisot, 1998; Liebowitz and Wilcox, 1997; Quintas et al., 1997), nevertheless, not only processes are fundamental for KM but also strategy and evaluation as evidenced before and highlighted by some others definitions of KM (i.e. Sveiby, 1997; von Krogh, 1998; Webb, 1998; Wiig, 1993).

With the proposal of understanding and synthesizing the KM literature about processes, the authors mapped the single phases and the KM cycles proposed. From the analysis 53 different phases have been identified from 35 authors. The authors have been classified in two categories:

- The ones proposing single phases (i.e. Alavi and Leidner, 2001);
- The ones organizing the phases into a cycle (they provide an order and a link among them; i.e. Wiig, 1993).

The papers analyzed have been divided according to the authors' nature: academics, consultancy firms and associations. Only 13 academics propose single phases isolated (Appendix A) while other academics, consultancy firms and associations provide a KM cycle (Appendix B). After a subdivision of the phases, for each one of these the frequency of citation in literature has been analyzed.

With the aim to propose a KM cycle in the next paragraph, the authors gathered the main phases, individualized the terms that are synonymous and which are the sub-phases. The selection of the main phases has been based on both on the number of

citations for each phase and the importance for the authors of the single phase, even if in literature some of them are less adopted.

In the figure 1 are proposed seven phases and the relative citation frequency (including synonymous and sub-phases).

		PHASES								
		ACQUIRE	CREATE	SHARE	STORE	RETRIEVE	APPLY	EXTERNAL TRANSFER		
FREQUENCE	not in a cycle	4	7	7	6	3	7	1	35	TOTAL
	in a cycle	7	11	7	3	1	7	0	36	
	TOTAL	11	18	14	9	4	14	1	**71**	

Figure 1. Frequency of the main phases

2.1 Acquire

The Knowledge acquisition phase refers to the sources used from the enterprise to achieve knowledge. It is possible to distinguish the source of knowledge in internal and external. The knowledge coming from internal sources possess a high value because is unique, specific and often in tacit form. The external knowledge tends to be more abstract, more expensive and available also for competitors. Often external knowledge is combined with the internal one with the aim to promote new intuitions. Joint ventures and partnerships for example are an important tool to obtain external knowledge in tacit form, not distributed and consequently with value for competition.

Gray and Meister (2004) define internal knowledge sourcing the access of an individual to the experience, knowledge and opinions of the colleagues. There are different ways to access to the knowledge of the others. The literature provides different contributes about this theme, for example tools in this direction are the communities of practice or knowledge repositories. An organization implements tools and organizational practices to facilitate the access to employees' knowledge thus reducing the research and transaction costs. It is possible to identify three knowledge sourcing adopting the perspective of a person learning: one to one, one to many and many to many (Harasim's, 1989). The first one refers to the personalization concept (Hansen et al., 1999), in this case the individual talks with colleagues to access their

knowledge. The communication channels are phone, mail, face to face meetings. The second one refers to the codification concept (Hansen et al., 1999), the individual accesses knowledge through database, manuals, etc. The third one is achieved through communities of practice, online discussion groups, where the knowledge exchange is among a lot of people. Also Parikh (2001) in his own KM Cycle assumes that the acquisition of knowledge is mainly through internal sources of the organization. Choi (2002) goes over the acquisition phase and describes also the sub-phase of selection. Therefore, the aim of knowledge acquisition is to bring inside the organization external knowledge. In conclusion, some authors develop an own analysis focused on internal knowledge sources, while others focus on the knowledge acquisition phase on external sources. Finally Tiwana (1999) with the term knowledge acquisition refers to the process of development and creation of intuitions, abilities and relations without explaining if they come from internal or external sources.

Lots of authors propose in their own internal KM cycle other phases that we consider as sub-phases such as adapt (O'Dell, 1996), capture (Dalkir, 2005), collect (APQC, 1996), evaluate (uit Beijerse, 1999), identify (Liebowitz, 1999), protection (Lee e Young, 2000), secure (Van Der Spek e Spijkervert, 1997), select (Holsapple and Joshi, 2002) and verify (Sunassee and Sewry, 2002). Only the sourcing (Wiig, 1993) phase has been considered a synonymous.

2.2 Create

Knowledge creation is connected with internal production of knowledge. This activity, in fact, is a central topic in most of the papers reviewed where it is often associated with the Organizational Knowledge Creation model (Nonaka and Takeuchi, 1995).

From an in-depth analysis of literature has emerged that Knowledge Creation is given different meanings: according to Bhatt (2000) *"...knowledge creation in organization is led through individuals"*. Holsapple and Joshi (2002) affirm that *"Generating knowledge is an activity of producing a unit of knowledge by processing existing units of knowledge, where the latter are the results of selection, acquisition, and/or prior generation"*. Also Choi (2002) states that *"Generation is an activity that produces knowledge by discovering it or deriving it from existing knowledge"*; both Choi and Holsapple and Joshi focus on recombination of existing knowledge. Rubenstein-Montano et al. (2001) instead reckon that the knowledge creation process must be related to customers' needs, in fact they affirm *"have open discussion with customers and interested parties, both internal and external to the organization"*.

Summarizing the different points of view of the literature, it is possible to say that some authors (Bhatt, 2000; Sagsan, 2006; Stankosky, 2005) sustain that knowledge is created by individuals which are a fundamental element in the knowledge creation cycle. Holsapple and Joshi (2002) focus on the process and not on the originators of new knowledge. Also Sunassee and Sewry (2002) reckon that the process of creation is based

on already existing knowledge. Of different opinion is Rubenstein-Montano et al. (2001) who states that knowledge creation originates from the discovery of stakeholders' needs (internal and external) and then aims at satisfying them.

As for the other phases, for the creation process the literature proposes different subphases: Rubenstein-Montano et al. (2001) clearly distinguishes between procedure and sub-procedure; others deal with the synonymous of combine (Van Der Spek and Spijkervert, 1997), construction (McAdam and McCreedy, 1999), develop (Knowledge Associates, 1999), generate (Ruggles, 1997), and the sub-phases compilation (Wiig, 1993), innovation (Lee and Young, 2000), learn (Liebowitz, 1999) and transform (Marquardt, 1996).

2.3 Share

Share is the most important phase in the management of knowledge (Dawson, 2000). In literature many words are used to refer to the activity of sharing; the most frequent is (internal) 'transfer' of knowledge (Huber, 1991). Sharing consist of making knowledge available among people and improve its exchange, use and reuse. The process of knowledge sharing is fundamental for the 'wheel reinventing' (Bender and Fish, 2000) because it creates a common understanding (Nickerson and Zenger, 2004), reduces uncertainty and transfers the individual learning to the organization (Nonaka, 1994). Therefore sharing refers to the flow of knowledge within the organization.

Bartol and Shrivastava (2002) define sharing as *"the action in which employees diffuse relevant knowledge to others across the organization"*, Dawson (2000) states that the final aim of knowledge sharing among employees is the transfer of individual assets and resources to the organization. Nonaka (1995) instead affirms that knowledge must be distributed and shared through the organization before being exploited. In synthesis some authors focus on the impact of knowledge sharing on individuals, while some others analyze the implication at the organizational level.

Leonard and Sensiper (1998), instead, analyze the barriers to knowledge sharing such as the lack of an appropriate culture and the organizational environment that prevent collaboration among people. Other barriers are: distance among persons, different cultural level, unwillingness to hand over own tacit knowledge and the fear of losing the benefits coming from the posses of knowledge.

The process of knowledge sharing is favoured by many factors analyzed in the literature. Trust is the most cited factor facilitating the sharing process (Adler, 2002; De Long and Fahey, 2000; McAllister, 1995; Nahapiet and Ghoshal, 1998; Tsai and Ghoshal, 1998). Along with this focus, some authors have analyzed the way to sharing process takes form; in particular Szulansky (1996) uses the term 'transfer' instead of 'sharing' and identifies a source and a destination point. Together with the above elements, also the knowledge features and the contest are considered.

Knowledge features refer to two properties: 'casual ambiguity' and 'non provability'. The first one is related to capabilities embedded into tacit knowledge; the second one to knowledge used in the past and not easily transferrable.

Holtham and Courtney (1998) propose four forms of knowledge sharing: informal, formal, personal and impersonal. Informal refers to informal meetings and chats that favour socialization. This approach doesn't facilitate the knowledge sharing along all the organization. Formal, instead, takes place through seminars and training sessions that transfer knowledge through all the organization but limit the level of creativity. Personal is related to the sharing of knowledge through personal channels which are effective for the transfer of context specific knowledge. Finally, the impersonal form of knowledge sharing is based on repositories which have a high level of explicitness (Alavi and Leidner, 2001; Karlsen and Gottschalk, 2004).

Therefore, knowledge sharing is a relevant phase in KM and for a comprehensive understanding of it a deep analysis on the reasons and factors that favour or limit it is required in order to reduce the barriers and increase the enablers.

The main synonyms used in literature are dissemination (Liebowitz, 1999), distribute (Nissen, 1999), transfer (Davenport and Prusak, 1998), and the sub-phases are connect (Herder et al., 2003), cooperate (Herder et al., 2003) integration (Lee and Young, 2000) and network (Herder et al., 2003).

2.4 Store

The store process consists in the knowledge patrimonialization, which is the knowledge that has been acquired and/or created by organization. For Beckett et al. (2000) the objective of the store process is to develop and maintain the knowledge base within the organization. In fact, in order to prevent the same inventions, an organization must store its knowledge and expertise (i.e. lessons learned).

An important sub process is the codification; knowledge must be codified in order to be stored. Based on the strategy adopted (codification or personalization) the organization will develop different ways to organize knowledge (organizational and individual memory).

In particular the individual memory is developed based on experiences, actions, observations, etc (Sanderlands and Stablein, 1987).

Organization must try to move the knowledge stored in the individual minds to organization, through the explicitation and codification processes in order to avoid lost of knowledge. Organizational memory is more than the sum of individual memory such as organizational culture, transformations, structure and informal archives.

The main synonymous are internalize (Hosapple e Joshi, 2002), structure (Sagsan, 2007) and synthesize (Accenture, 2000) while the sub-phases are codify (Ruggles, 1997), consolidation (Van Heijst et al.,1997), embodiement (McAdam e McReady, 1999), formalize (Nissen, 1999), organize (O'Dell, 1996), representation (Knowledge Associates, 1999) and retain (Diakoulakis et al., 2004).

2.5 Retrieve

The retrieving process identifies the recovering of knowledge necessary for the development of an own job. An organization must try to simplify the retrieving of knowledge stocked to reduce the time to access and guarantee the retrieval unit of knowledge.

Diakoulakis et al., (2004) affirms that if the data is well structured this condition allows to improve the retrieve process. To do this it is necessary to possess ICT systems easy to use but at the same time efficient to find out quickly the information needed. If the object of research is tacit knowledge, it must be identified which are the people that hold that one, for example the experts, and link these ones with the other members of the organization.

Stenmark (2001) affirms that the knowledge codification is not necessary for the organization but it is essential to map tacit knowledge for the retrieve.

The retrieve is linked to the store process as different ways of storing imply the adoption of different tools and they have direct implication in the share process. In particular, for this one, if an organization built an efficient system for storing information also the retrieve process will be more easy. In other words, if in an organization there is an environment that will favor a share process the access (research more complete and depth) will be more easy.

The main sub-phases are, analyze (Herder et al., 2003), audite (Sagsan, 2007), explore (Herder et al., 2003), review (Bhatt, 2000) and tracking (Herder et al., 2003) while a synonymous is access (Diakoulakis et al., 2004).

2.6 Apply

Knowledge application is the fundamental process because allows the creation of value (Alavi and Leidner, 2001) and the maintaining of competitive advantage in comparison with competitors (Beckett et al., 2000). Holsapple and Joshi (2002) use the word externalize with the focus on the organization ability to realize new outputs to introduce in the market. Both Shin et al. (2001) and Tonchia et al. (2003) treat application as a source of competitive advantage.

Knowledge applied allows an interiorization (Nonaka, 1994) and the learning of new knowledge (Parikh,2007) providing source for a new KM cycle.

Knowledge application provides indirectly the financial resources necessary for the next research and innovation activities. Research without application is not economically sustainable in the long period. At the same time application without research could be impossible.

The main synonymous are externalize (Holsapple e Joshi, 2002), sell (Liebowitz, 1999), use (McAdam e McCreedy, 1999), utilization (Marquardt, 1996) and the only sub-phase is value realization (Wiig, 1993).

2.7 External transfer

External transfer is explicitly treated only by few authors (i.e. Beckett et al. 2000), in fact, as in literature this process is included in the apply process. Beckett et al. (2000) highlight that the apply process is when there is an internal exploitation, while external transfer when there is an external exploitation, in general the selling of knowledge like patents (Beckett et al., 2000). In this case it's a controlled transfer of only a part of defined knowledge. Also exaptation ideas that are successively sold to a proper firm are a typical example of external transfer. In the case of consultancy firms, the external transfer is their core business, in fact they use own knowledge to support or improve the activities of the customers.

The literature analysis proposed has evidenced the presence of a wide nomenclature for the development of a knowledge management cycle, almost with the aim to propose some new names to find out new characteristics. Every KM cycle analyzed has a value and it to stresses majorly some characteristics of the KM rather than other ones. This literature analysis allows to clarify the terms used more and it is a strong base to develop the next part of the paper.

3 Knowledge Management Cycle proposed

After a literature analysis a complete map of the knowledge management cycles has been designed. The new approach used to design the knowledge management cycle is the material conservation law although the authors' consciousness that knowledge and classical resources have very different properties. The knowledge management cycle proposed is based on nine phases and allows to understand which are the more evident phases managed inside the organization and it is basically to propose a classification of KM tools.

Material conservation law

ENTRY – EXIT + PRODUCTION – CONSUME = STOCK

The assumption is that knowledge (with peculiar characteristics: multipliable, indivisible and reflexive) is associated as a material resource (with classic characteristics: scarce, divisible and instrumental) and for this reason subjected to the same conservation law.

Based on the previous processes analyzed, the application of the material conservation law to the knowledge allows to identify the following relation:

Application of the material conservation law to knowledge

ENTRY – (EXTERNAL TRANSFER+ LOSS) + PRODUCTION – OBSOLESCENCE = STOCK

Where:

- **Entry**: is the external acquisition of knowledge that is brought inside the organization in several ways: employment engagement, technology buying, collaborations with universities and research centres, alliances, etc.
- **External transfer**: is the controlled cession of knowledge towards the external boundaries of the organization through patents selling, royalties, etc.
- **Loss**: is the deprivation of tacit knowledge not shared of the people that leave the organization. The "sum" of external transfer and loss of knowledge is the total of exit.
- **Production**: is the creation of knowledge.
- **Obsolescence**: is the knowledge not used anymore by organization due to technological progress or normative evolution. The obsolescence is linked to the material consumption.
- **Stock**: is the sum of tacit and explicit knowledge present in the organization.

The characteristics of knowledge compared with the traditional resources impose to define:

- four specific phases for the "production" of knowledge:
    - Create;
    - Share;
    - Store;
    - Retrieve.
- a specific phase for the use of knowledge
    - Apply.

The single phases are:

- **Acquire** in which way the organization trace knowledge from the external environment.
- **Create** is the process that is originated from the individual of an organization, that through own experiences, relations with others and with the environment generate new knowledge.
- **Share** permit to give available the knowledge to make easy both exchange and interaction among people. Knowledge must be shared among people to be fully exploited (Nonaka and Takeuchi, 1995).
- **Store**: consist in the saving of knowledge (tacit and explicit), to avoid to recreate knowledge or rethinking solutions (Beckett et al., 2000, Lai and Chu, 2002).
- **Retrieve**: it is the extraction of knowledge presence in the internal resources (database and people).
- **Apply** means the development of new products, technologies, services. This process generate a competitive advantage and a value added.

- **External transfer** can be considered the process that allow to "bring out" from the boundaries of the firm the knowledge internally produced.
- **Loss** that happen when a person of the organization leaves. This problem is more evident if the knowledge if in tacit form; Jasimuddine et al. (2005) affirms that the major problem for an organization that use tacit knowledge is the risk to loss that knowledge through the dismissal of employees.
- **Obsolescence** is a process in which the knowledge decline and it is erode (Zack, 2005); it's linked to external factors not controllable by the organization and it is linked to the industry where the organization operates.

The resultant of the cycle is:

- **Knowledge stock**, the whole of knowledge that an organization posses that resides as tacit knowledge in the people and as explicit knowledge in database, procedures, ecc. The knowledge stock is the result of the entire knowledge management cycle with some processes as input (acquire, create, share, store) and some others as output (retrieve, apply, loss, obsolescence and external transfer).

The material conservation law applied to knowledge and the peculiar characteristics of this one identify nine phases that compose the KM cycle (acquire, external transfer, loss, create, share, store, retrieve, obsolescence and apply) and determine the final stock of knowledge (figure 2).

The major part of these processes (seven out of nine) emerged from the literature analysis. The knowledge loss and the obsolescence can be considered "exogenous" not manageable by the organization, while the other seven processes are "endogenous" actively controllable by the organization.

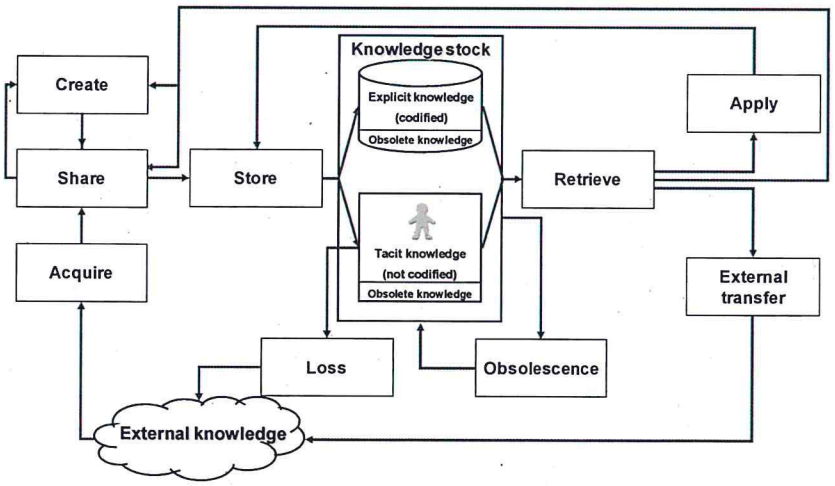

Figure 2. Knowledge management cycle proposed

Knowledge Management cycle can be useful also for classifying tools adopted by organizations. From the literature analysis have been identified authors that discuss about tools of KM: some propose only a list of various tools used for KM (i.e. uit Beijerse, 1999; Nissen et al., 2000; Geisler, 2007) while others identify KM tools starting from a case study research (i.e. Gray, 2001; Rao 2005).

With the aim to propose a matrix for classifying KM tools, some concepts emerged in literature have been taken into consideration.

Meroño-Cerdan et al. (2007) identify two categories of tools:

- technological ones;
- organizational and managerial ones.

This is the first dimension of the matrix. The second dimension refers to the phases of the KM cycle. This matrix allows to observe which are the phases most managed and in which phases an introduction of a new tool brings an impact.

4 Methodology

To address these questions the present research adopts the descriptive case study research design, as defined by Yin (2003) and McCutcheon and Meredith (1993). The study case approach allows to undertake an investigation that maintain the holistic and significant characteristics of the organization (Yin, 2003).

Robson (1993) defines explorative study a method to discover "what happen" to propose questions and to observe the phenomena from a new perspective.

The paper will deeply investigate a single case study even if the research take in considerations three ones.

The company analyzed designs, develops and markets nano personal and high performance computers and its 2008 revenues amounted to 90 million euro. This company owns different branches with 9 firms working in Europe (4), America (3) and Asia (2). The company employees 624 persons and 174 of these operate in the research and development departments.

5 Empirical evidences from case study

The case study allowed a complete understanding of the main knowledge flows inside the organizations. An analytical description of the single phases will be proposed and successively will be described the tools adopted that can have an impact in the KM cycle.

5.1 Knowledge Management cycle

The single phases for the company analyzed are:

- *Acquire*: the company acquired numerous firms with the aim to enter in new markets and to complete the portfolio products. With this strategy, the company absorbs knowledge stock from other firms. Moreover, with the aim to develop new

and high innovative projects to focus on disruptive technologies for the tomorrow customers, it defines numerous collaborations with universities and research centers.

- *Create*: this phase has been supported in two different areas of the firm, in the central research center (laboratory) and also in the several R&D areas of the group firms. The research projects, initially developed within the universities through collaborations agreements, are completed inside the laboratory. This phase, called "last miles", allows to transfer the tacit knowledge but also to create new one. Inside the several R&D areas of the single group firms, the knowledge creation has been conducted through the reengineering phase of the concept product transmitted from the laboratory, but also through the satisfaction of specific market needs and through the exchange of information with the other firms of the group.
- *Share*: this phase, such as the create phase, can take place between the research area (laboratory) and the development areas and also among the same development areas. In the first case the share phase happens through a transfer of explicit knowledge (documents and reports) about the product concept with an eventual support from the laboratory researcher. In the second case the single firms of the group share both explicit knowledge (product characteristics, best practice, etc.) and tacit knowledge through transfer of persons for a limited time in the other companies of the group.
- *Store*: The company decided to standardize the codification of the documents shared among the group firms but not the internal ones. These practices allow to realize a gradual cultural change and to create a collaboration environment without radically change the organizational practices of the acquired firms of the group. Each firm of the group has an own database, nevertheless the company is working to create a unique shared database divided in several interesting areas: the introduction of this tool is very expensive and impacts on the major part of the processes of the firm.
- *Retrieve:* the enterprise has implemented a system to retrieve the codified knowledge mainly through SharePoint® that allows to trace both codified knowledge and presence of people.
- *Apply:* the enterprise through the customers feedback tries to improve the product while the knowledge coming from the research network and laboratory develops into new products aligned with the knowledge business vision of miniaturization and connection of the products.
- *External transfer*: The company only in one occasion provided technology to support an enterprise start-up. The company transferred own knowledge and technologies to a start up, a web-farm that provides web services. In this case the company could test own technologies and products dedicated to network management.

- *Obsolescence:* this is a phase present in the company analyzed, in fact, the company operates in an industry with continuous and rapid changes in technology that incorporated an high rate of obsolescence.
- *Loss:* this phase is of limited importance for two reasons: the high rate of obsolescence of the sector causes a reduction in the strategic relevance of the knowledge developed in the past, in particular, the disruptive technologies are based on an epistemological base different from the knowledge already developed in the past. Moreover, a high level of codification means reduces the loss of knowledge connected to employee turnover

5.2 Knowledge Management tools

Seven main KM tools have been identified in the company that provide an influence to the KM Cycle (figure 3).

		PHASES						
		ACQUIRE	CREATE	SHARE	STORE	RETRIEVE	APPLY	EXTERNAL TRANSFER
MANAGERIAL AND ORGANIZATIONAL TOOLS	Mergers and acquisitions	✓						
	Separated departments of research and development	✓	✓	✓				
	Collaborations with universities and research centers	✓	✓					
	Scientific Committee	✓						
ICT TOOLS	SharePoint®			✓	✓	✓		
	Shared database			✓	✓	✓		
	Centralized ERP				✓	✓		

Figura 3. KM Tools of the case study

Mergers and acquisitions

Between 2002 and 2007 the company acquired seven national and international firms with the aim to enter in new markets (USA, Japan) and in new market sectors (defense and transport). The acquisition of firms geographically distant and culturally different increased the "not invented here" syndrome, already present in some departments: different language, culture and behavior have generated communication problems among firms. When the company completed the acquisitions started to reorganize and develop initiatives to overcome those problems. With a KM perspective the company introduced ICT tools to favor the communication among the firms of the

group and also promoted periodic transfer of people in the other firms to share and map the knowledge in the others firms.

Separated departments of research and development

The company, with the aim to develop new ideas and to support innovation, divided in two distinct departments the research and development function. For the research it created a laboratory, founded in 2005, to focus own resources in activities and projects fundamental at a strategic level (NanoPC e HPC). The laboratory with 15 employees would be the place where to encourage the ideas of young researchers; it also has a strong link with universities but also with the industry. The laboratory manages the research projects with universities and research centers, but the main activity is to follow the final steps of the projects, preparing to the next phase of development that will be realized from one of the single firms of the group (development departments). The objective is to acquire knowledge from the external environment to develop potential new business. Moreover, the company is designing little communities of research in others research centers or in other firms of the group.

Collaborations with universities and research centers

The Company undertakes research both within its organization through an own laboratory and with the external environment through collaborations with universities and research centers. The laboratory is in charge of the coordination and relationship management with the external sources with the aim to bring inside and absorb all the knowledge and the competences useful for the development of new businesses.

Nowadays the laboratory manages 12 research projects with 9 public and private research centers. The outsourcing of part of the research activities and the development of an external research network are a new strategic decision as until few years ago all the research was internally conducted. The choice of the research collaborations is based on the following requirements:

- R&D of a certain level of quality;
- Affinity between research projects aims and the company development scenarios;
- Willingness of imagining the future.

The acquisition and the transfer of knowledge within the laboratory is a gradual and transparent process for both the partners involved. The company purpose while setting research collaborations is not aimed at exploiting the partner knowledge but to help and sustain these centers that do not have enough resources to bring their ideas and new products in the market.

For this reason the company establishes different levels of collaboration:

- When the project is still in a start-up phase and far from relevant applications, the research is completely handled by external personnel such as ph.d students or university researchers. In this case the project is funded by the company through scholarships.

- When the project advances and some possible interesting applications have been identified, the contacts with the university/research centers and the researches increase. Step by step the research is then brought into the company laboratory and managed by its personnel.
- The project is finalized within the laboratory where the 'last mile' is undertaken which results in a concept product.

The concept product is then transferred to the development department where it is re-engineered or totally redesigned. The prototype realized is then proposed to some markets and clients with the aim to get useful feedback. Research and Development are completely separated: this structure allows the development department to design and re-engineer the product according to the market needs without being influenced by the work done in the research staff.

Both the laboratory and its network collaborations have been set up to acquire and develop knowledge but they are also relevant in organizational and managerial terms. The research, therefore, is conducted externally and the laboratory plays a relevant role in coordinating the research network. According to this, it is clear that the laboratory needs both technical competences related to the research projects and managerial ones in order to effectively manage the network created.

Scientific Committee

A scientific committee has also been established with 10 experts of the sectors where the company competes. The committee's aim is to assist the strategic and research planning, to identify new market opportunities, to foster collaborations with research centres and to check the 'state of the art' of markets and technologies. Its final objective is to help in correctly addressing the research activities.

SharePoint®

To facilitate the acquisition and the gathering of tacit and explicit knowledge from all the companies of the group, an intranet supported by Microsoft SharePoint® has been created. SharePoint® is a scalable portal that allows people connection and information sharing. Its features of data aggregation, organization and research facilitate collaboration among final users. SharePoint® has been introduced in the company with three purposes: customisation, integration and collaboration. Customisation allows the information operators to create and manage personal sites organizing data according to specific research themes, recipient groups or topic. Important is the decision of the company to use SharePoint® adopting a group perspective instead of an individualistic one: for this reason there are no 'private' places in the intranet but only group ones. Private enterprise is encouraged and awarded, but it has to create value and opportunities for all the group (and the company) and not only for the individual.

Integration and collaboration refer to the sharing of documents, ideas and knowledge. The company objective is to use ICT tools to favour and facilitate exchange of ideas and knowledge and foster employees' relationships and communication on

specific topics. Throughout SharePoint® all the employees, regardless where they are located, can easily access and share information, data and knowledge.

Shared database

The company is also projecting the realization of a shared knowledge based: some areas of the intranet, in fact, have been dedicated to the sharing of technical knowledge about projects and products. At the moment only the marketing and sales departments have been involved in order to sale all the products to all the companies of the group. Before the setting of this project, each company used to gather its explicit knowledge in own databases not accessible to the other members of the group. For this reason the group leader company decided to implement a shared database with dedicated sections for each department. Up to know the project has involved 6 companies but it will be completed by the end of the year.

Centralized ERP

A similar solution has been implemented with reference to the ERP system. Each company had an own ERP and this situation caused problems in data sharing and transfer. So, to prevent barriers in data sharing, a single ERP has been set up in all the group. This project started in USA branches and in 2009 was expanded to all the others. Along with the implementation of a shared database, the set up of a single ERP system has required remarkable investments that involved all the company processes. The group leader reckons that these efforts will favour cohesion, collaboration and efficiency among the companies of all the group.

In figure 4 the graphical representation of the KM tools in KM cycle.

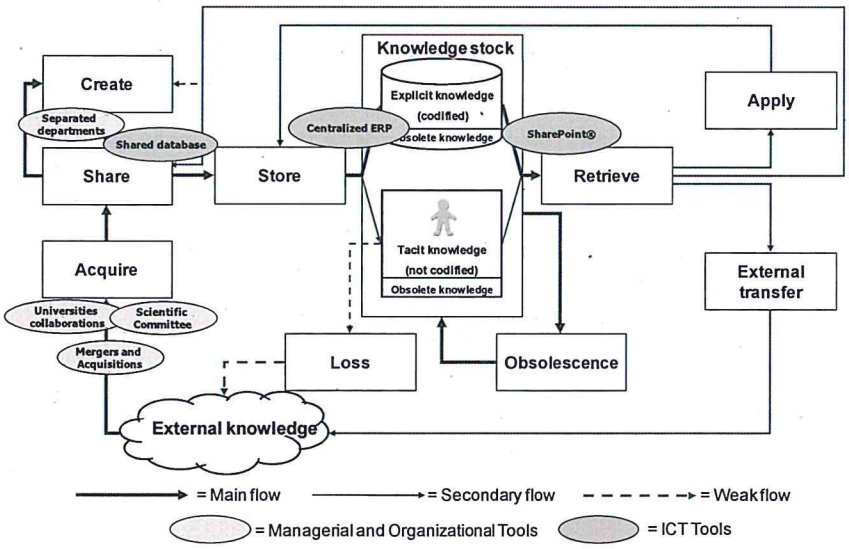

Figure 4. Knowledge Management cycle and tools in the case study

6 Conclusions

Literature highlights that knowledge provides even more a competitive advantage in a knowledge economy. For this reason there is the need to develop tools that allow to manage this resource and to support this perspective.

The knowledge management cycle proposed was build up starting from a deep literature analysis as well as the matrix KM tools classification moves in this direction.

The case study allows to understand how the company introduced own tools in order to acquire knowledge from the environment. Most of these ones are managerial and organizational with strong relationships among them that guarantee a continuous flow of knowledge inside the organization. Knowledge is dispersed and present in the head of the persons. The case study shows how the company with KM tools tries to structure the acquisition of knowledge from the external environment and share it inside the organization.

The knowledge management cycle can be used to analyze the tools and practices adopted by the organization to manage knowledge. In this way enterprises can understand, from an alternative perspective, their own organization and find out strengths and weakness in the knowledge processes.

Understanding which are the most and less important phases for the organization could be useful to orientate a conscious management of knowledge.

Knowledge management cycle should be introduced as a fundamental tool in the management. If in literature there is evidence of the role played by knowledge in organizations, there is also the need to develop structured tools that aim to manage this resource.

Future direction of the research can be the identification of the relationship between the management area and the strategy and evaluation ones. Moreover, starting from the material conservation law, could be interesting to study how many other concepts from the traditional law of physics can be reinterpreted in the knowledge management perspective.

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Appendix A – List of phases proposed by author (not in a cycle)

Phases / Authors	Van Heijst et al, 1997	Liebowitz and Beckman, 1998	Uit Beijerse, 1999	Tuvana, 2000	Beckett et al., 2000	Alavi and Leidner, 2001	Robertson-Montano, 2001	Standards, 2001	Kasvi et al, 2003	Harder et al, 2003	Tomchia et al, 2003	Diakoulakis et al., 2004	Stankosky et al., 2005
ACCESS												X	
ACQUIRE				X	X			X			X		
ADAPT													
ANALYZE										X			
APPLY		X	X	X	X	X			X		X		
AUDITE													
CAPTURE		X					X						
CODIFY													X
COLLECT													
COMBINE	X						X					X	
COMPILATION													
CONNECT										X			
CONSOLIDATION	X												
CONSTRUCTION													
COOPERATE										X			
CREATE		X				X	X	X	X		X	X	
DEVELOP	X		X										
DISSEMINATION													
DISTRIBUTE	X										X		
EMBODIMENT													
EVALUATE			X										
EXPLORE										X			
EXTERNALIZE													
TRANSFER					X								
FORMALIZE													
GENERATE		X											X
IDENTIFY													
INNOVATION													
INTEGRATION										X			
INTERNALIZE													
LEARN							X		X				
NETWORK										X			
ORGANIZE							X						
PROTECTION													
N							X						
RETAIN												X	
RETRIEVE									X	X	X		
REVIEW													
SECURE													X
SELECT		X											
SELL		X											
SHARE	X	X	X	X			X	X			X	X	
SOURCING													
STORE		X				X	X		X	X	X		
STRUCTURE													
SYNTHETIZE													
TRACKING										X			

Appendix B – List of phases proposed by autors (in a cycle)

Authors \ Phases	ACCESS	ACQUIRE	ADAPT	ANALYZE	APPLY	AUDITE	CAPTURE	CODIFY	COLLECT	COMBINE	COMPILATION	CONNECT	CONSOLIDATION	CONSTRUCTION	COOPERATE	CREATE	DEVELOP	DISSEMINATION	DISTRIBUTE	EMBODIMENT	EVALUATE	EXPLORE	EXTERNALIZE	EXTERNAL TRANSFER	FORMALIZE	GENERATE	IDENTIFY	INNOVATION	INTEGRATION	INTERNALIZE	LEARN	NETWORK	ORGANIZE	PROTECTION	REPRESENTATION	REUSE	RETRIEVE	REVIEW	SECURE	SELECT	SELL	SHARE	SOURCING	STORE	STRUCTURE	SYNTHESIZE	TRACKING	TRANSFERING	TRANSFORM	USE	UTILIZATION	VALUE REALIZATION	VERIFY
Wiig, 1993					X						X					X	X																										X						X			X	
Marquardt, 1996		X														X																												X							X		
O'Dell, 1996			X		X				X							X											X						X									X										
Ruggles, 1997								X																		X																						X					
Van der Spek and Spijkervet, 1997										X							X		X																			X															
Davenport and Prusak, 1998								X																		X																						X					
Liebowitz, 1999							X			X						X		X									X				X		X				X		X		X								X				X
Mc Adam and Mc Creedy, 1999														X				X		X																													X				
Nissen, 1999					X		X												X						X								X																				
Bhatt, 2000			X													X			X																			X															
Lee e Young, 2000		X																X										X	X					X																			
Parikh, 2001		X			X													X																									X										
Holsapple and Joshi, 2002		X																					X			X				X									X											X			
Sumassee and Sewry, 2002							X			X						X		X									X						X				X												X			X
European, 2004																X											X														X		X						X				
Dalkir, 2005		X			X		X									X		X																							X												
Sagsan, 2007						X										X																									X			X				X					
Ernst and Young, 1999 *					X			X																		X								X																			
Gartner Group, 1999 *	X						X									X																	X																X				
Knowledge Associates, 1999 *		X															X																	X							X												
Accenture, 2000 *		X																X																							X				X				X				
APQC, 1996 **			X		X				X							X											X						X								X												

* =Consultant firm, **=Association