

A Framework for Characterizing Knowledge Management Systems

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Abstract: This paper presents a framework for characterizing knowledge management systems (KMS). The framework has a descriptive nature and aims to be useful both to characterize and to drive KMS implementations, facilitating the identification and selection of appropriate tools according organization needs. A review of KMS categories was made to identify their underlying assumptions and purposes, and a systematization of intellectual capital (IC) measurement models was developed with the purpose of identifying the main components normally used to measure IC and to analyse if those measures are addressed by KMS.

Keywords: Knowledge Management Systems; Knowledge Management; Intellectual Capital; intellectual capital measurement.

1. Introduction

KM refers to managing knowledge processes that facilitate the development and application of organizational knowledge. The main purpose of KM is to maximize knowledge-related effectiveness processes with the aim to create value for the organization (Zhou and Fink 2003; Carlucci, Marr et al. 2004). KMS are automated tools that contribute to support KM processes, namely knowledge creation, storage and retrieval, transfer and application (Alavi and Leidner 2001; Lindvall, Rus et al. 2003), and the flows between them. On the other hand, evaluating the economic impact of knowledge in organizations, i.e., the IC measurement is a key issue in KM (Carrilo, Robinson et al. 2003; Chamorro, Roy et al. 2003). In fact, many KMS implementations are viewed as failures as a result of the difficulty in measuring their benefits to the organization (Davenport and Prusak 1998; King and Ko 2001; O' Dell 2004).

The aim of this paper is to present a framework for characterizing KMS considering the above referred aspects. The framework describes the role of KMS in supporting knowledge related processes, knowledge conversions flows and IC components measurement features.

According to Nonaka (Nonaka and Takeuchi 1995), knowledge flows are based on dynamic processes of knowledge conversion between the tacit and the explicit dimensions. These knowledge conversion cycles and the main KM processes that KMS need to support are described in the second section of this paper. A review of KMS classifications is made in the third section with the purpose of identifying their underlying assumptions and functionalities, and to highlight the different categories that are normally used to classify KMS. The research about IC measurement has produced several approaches and models over the last few years. Section four provides a systematization of IC measurement models with the purpose of identifying the main components used to measure IC. Section five describes the framework for characterizing KMS, its use and benefits. The framework is used to analyse the role of KMS categories in three perspectives: knowledge processes supported, knowledge flows and conversion cycles and features related with the IC measurement.

2. Organizational Knowledge

2.1 Knowledge Conversion cycles

Organizational knowledge is created through conversion between tacit and explicit knowledge (Nonaka and Takeuchi 1995). Knowledge conversion from one form to another occurs frequently and leads to the creation of new knowledge. According to Nonaka, tacit knowledge can be useful to organizations only if it is converted to its explicit form which can be used. Figure 1 shows Nonaka model where a knowledge spiral results in the theory of organizational-based knowledge creation by the interaction of four activities: combination, internalization, socialization and externalization. This

dynamic process of knowledge conversion is based on knowledge flows across individuals, groups and organizations.

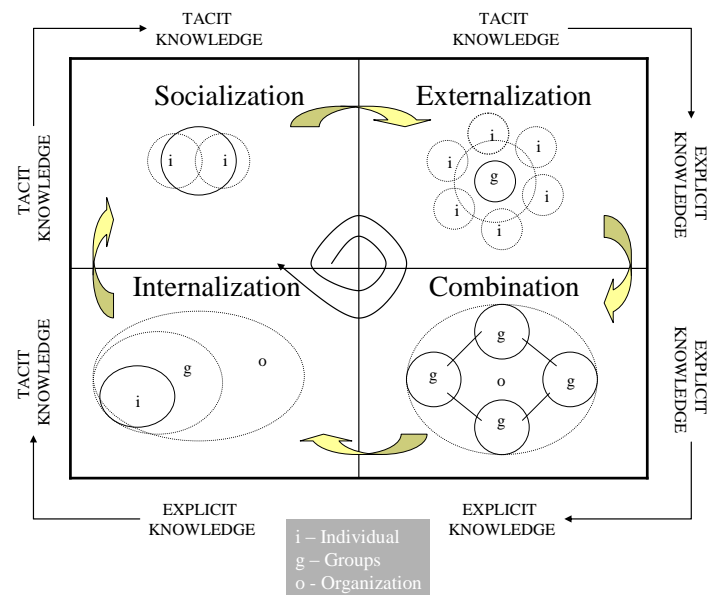


Figure 1 – The Nonaka knowledge creation model. Font: adapted from (Nonaka and Takeuchi 1995)

Explicit to explicit conversion, or combination, is the reconfiguration of existing knowledge like sorting, adding, combining and categorizing documents or manuals. Explicit to tacit conversion, or internalization, consists on knowledge assimilation; it is the human act of assimilating the explicit knowledge by reading and learning, for example. Tacit to explicit conversion, or externalization, is the process of converting personal knowledge into codified and documented knowledge that can be stored, like writing a best practices report or a procedure manual. Tacit to tacit conversion, or socialization, results from the interactions and exchange of ideas between people. It occurs by sharing experiences and by direct exchange of knowledge, through conversation, electronic meetings, instant messaging or communities of practice.

2.2 knowledge Management Processes

Accepting the idea that the aim of KMS is to support and enhance knowledge processes, it is important to identify the different processes that KMS need to support and to adopt a classification that will be used to further analyse and discuss the role of KMS in organizations. According to Pinto (Pinto, Lopes et al. 2005), there is a greater emphasis on processes related with knowledge creation, knowledge storage and retrieval, knowledge transfer and knowledge application or usage (Ruggles 1997; Alavi and Leidner 1999; Queen’s 2000; Alavi and Leidner 2001). These processes are going to be adopted in the context of this research:

- Knowledge creation involves the generation and discovery of new knowledge. It includes activities such as acquisition, synthesis, fusion and adaptation of existing knowledge.
- Knowledge storage and retrieval consists in the codification, organization and representation of knowledge such that it can be accessed. It includes activities that preserve, maintain and index knowledge for easy browsing and searching.
- Knowledge transfer refers to the activities of knowledge dissemination and distribution within a community, through a specific channel. It can occur at various levels: individuals, groups, organizations or inter-organizations.
- Knowledge application is the fundamental scope for KM. Competitive advantage resides in the application of knowledge, rather than in the knowledge itself. It includes activities and events related with the application of knowledge to business processes.

3. Knowledge Management Systems Systematization

KMS are automated tools that support KM processes in organizations. In order to better understand their contribution to KM, a review of KMS classifications was made. The main purpose of the review was to classify KMS regarding their addressed issues, capabilities and functionalities (Davenport and Prusak 1998; Mason 1998; Jackson 1999; Baroni 2000; Microsoft 2000; Queen’s 2000; Wensley 2000; European KM 2001; Lindvall, Rus et al. 2003; Loureiro 2003; Nantel 2003; Amaral and Pedro 2004; America 2004; Gramatikov 2004). Based on the diversity of classifications proposed by authors, a systematization of KMS categories was developed. Table 1 summarizes this systematization presenting, for each category, the main functionalities.

Table 1 – Knowledge management systems classification

Categories	Main functionalities
Document management systems	Document management; edition collaboration; control version; share documents; support all content types (text, audio, video, graphs, xml, web, etc.); search and retrieval advanced mechanisms.
Knowledge maps	Categorization and indexing knowledge in taxonomies; create knowledge maps; appoint to organizational knowledge; insert tags and labels in documents; alert to relevant information; knowledge auditing.
Collaboration systems (groupware)	Synchronous or asynchronous communication; process and people collaboration; virtual meetings; instant messenger, videoconference; real-time conversation; group calendar and scheduling, etc.
Workflow systems	Business processes automation; support automated flows of activities, tasks and information; support documental flows.
Business intelligence	Statistical, OLAP analysis; reveal patterns and hidden relationships between data; generate new knowledge from existing data and knowledge bases; support to decision-making; query and reporting tools; data mining and data warehousing tools.
Expert systems	Expert identification; connect users with experts to solve certain problems; ask questions, provide recommendations and explain logical processes; capture and store new questions and rules in a knowledge base.
Competence management	Employees profiles; experts, customers, vendors or others profiles in some systems; competence maps; individual competence analysis; training programs recommendation based on employees skills; recruitment and selection candidates support.
E-learning systems	Environment personalization; evaluation and progress tracking; exercises quiz and tests; collaboration tools; reusable learning and object libraries; support different types of contents: text, audio, video, etc.; classes workgroups; authoring, scheduling and reporting tools; searching and matching tutorials.
Customer relationship management	Self-desk and help-desk functionalities; FAQs access and maintenance; on-line customer support; expert help; customer profiles; customers queries.
Corporative portals	Environment personalization; filtering relevant information; search and retrieval advanced mechanisms; news, activities, tasks and calendar management; unified access environment to other tools: documents management, workflow, knowledge maps, groupware, etc.; integration with other applications: ERPs, CRMs, etc.

4. Intellectual Capital Measurement

IC is the set of intangible assets that can create wealth in organizations, including processes, technologies, patents, employee’s skills and relationships. Its measurement reflects the influence and the economic impact of knowledge in the organizations (Edvinsson and Malone 1997; Edvinsson, Roos et al. 1998; Allee 2000; Lev 2002; Leliaert, Candries et al. 2003; Martí 2003; Pike and Roos 2004). Measuring the value of knowledge and their impact in the organizations is a key issue of KM. In fact, a KMS should not only support knowledge flows and knowledge transformations between the tacit and explicit dimensions of knowledge, but should also be able to define some measures that

evaluate the intangible assets and their benefits in the organizations (Carrilo, Robinson et al. 2003; Iftikhar 2003; CENa 2004; APQC 2005).

There is a general agreement that intangible assets may be decomposed in a set of components. A systematization of IC measurement models was made with the purpose of identifying the main components used to measure IC. Table 2 summarises these IC measurement models describing the components identified in each one.

Table 2 – A systematization of intellectual capital models and components

IC Components IC Measurement Models	Financial Capital	Human Capital	Structural Capital	Relationship Capital	R&D capital/ Intellectual Property	Social Capital	Environment Capital	Corporate Identity
<i>Skandia Navigator</i>	X	X	X	X	X			
<i>Balanced Scorecard</i>	X		X	X	X			
<i>Intangible Assets Monitor</i>		X	X	X				
<i>Intelect Model</i>		X	X	X				
<i>Intellectual Capital Index</i>		X	X	X	X			
<i>Modelo Nova</i>		X	X	X	X			
<i>Intangible Value Framework</i>		X	X	X		X	X	X
<i>IC – Rating</i>		X	X	X	X			X
<i>Intellectual Capital Rating</i>		X	X	X	X			
<i>Modelo de Heng</i>		X	X	X	X			X
<i>Meritum Guidelines</i>		X	X	X				
<i>Danish Guidelines</i>		X	X	X	X			
<i>Value Chain Scoreboard</i>			X	X	X			
<i>Modelo de Chen, Zhu e Xie</i>		X	X	X	X			
<i>Intellectus</i>		X	X	X	X	X	X	
<i>Technology Broker</i>		X	X	X	X			
<i>Citation-Weighted Patents</i>					X			
<i>Inclusive Valuation Methodology</i>		X	X	X				
<i>Total Value Creation</i>		X		X				
<i>The Value Explorer</i>		X	X		X			
<i>The 4-Leaf Model</i>		X	X	X				
VAIC		X	X					

It is important to note that the financial capital isn't an IC component. It appears in table 2 because *Skandia Navigator* and *Balanced Scorecard* models suggest indices to measure the financial capital in complement to IC. Based on this systematization, some important conclusions can already be drawn:

- Some authors specify different names to describe similar components. For example, external capital, relationship capital or customer capital are very similar components. On the other hand, individual competence or human capital describes the same set of intangibles assets.
- The most common IC components addressed in the literature are: human capital, structural capital and relationship capital. However, there are some exceptions: the *Balanced Scorecard* and the *Value Chain Scoreboard* models don't refer to the human capital; the *Value Explorer* and the *VAIC* models don't specify the relationship capital; the *Citation-Weighted Patents* is a particular model that measures only the intellectual property assets.
- The R&D capital appears in some models, but it is frequently a subcomponent of structural capital. In some cases it appears associated with the intellectual property assets.
- Other components, like social capital, environment capital or corporate identity appears in a small number of models, depending on their own characteristics.

Although the names may vary, most authors refer to IC as consisting of a set of human, relationship and structural or organizational capital (Brooking 1996; Edvinsson and Malone 1997; Allee 2000;

Sveiby 2001). Some IC measurement models break down these components into such subcomponents as intellectual property, R&D capital, social capital, environment capital or others, depending on their own characteristics. Following is a short description of the IC components most common addressed in the literature. Those will be adopted in the context of this research to further analyse the contribution of the KMS categories to the IC measurement.

- Human capital: is concerned with individual capabilities, knowledge, skills, experience and solve problems abilities that reside in organizations people.
- Structural capital: is concerned with systems, work processes, technologies, concepts and models of how business operate, databases, documents, patents, copyrights and other codified knowledge.
- Relationship capital: is concerned with alliances and relationships with customers, partners, suppliers, investors, communities. It includes brand recognition, organization image and market position.

5. A Framework for Characterizing KMS

5.1 Framework Description: its usage and benefits

The framework is going to be represented as a table that can be used as a tool to list, classify and systematize KMS capabilities, facilitating the selection of appropriate tools according to the organization strategy and needs. It has a descriptive nature and provides an interpretative picture that helps to analyse and to drive the implementation of KMS in organizations. Table 3 shows a template for the framework.

Table 3 – Template for KMS framework

KMS Categories	KM Processes				KM Conversion Flows				IC Components Measured		
	Creation	Storage & retrieval	Transfer	Application	Combination	Internalization	Socialization	Externalization	Human capital	Structural Capital	Relationship Capital

For each KMS category, it is possible to highlight the most relevant characteristics, or attributes, by putting an X in the corresponding features. The usage of the framework can bring some benefits to the organizations:

- The framework can facilitate the understanding of the role of each KMS in a KM project. It helps to organize and classify KMS, identifying and differentiating the role of each one.
- The framework can be used to compare characteristics of different KMS, facilitating their selection according the organization needs.
- The framework examines the flows between tacit and explicit knowledge supported by each KMS, which facilitates the understanding of interactions and dependencies among individuals and groups across the organization.
- The framework can be used to identify the KMS that establish a link between KM and IC measurement. Considering the potential interest in measuring the value of knowledge and their impact in the organization, the framework could facilitate the identification of the KMS that specify indices to measure IC components.

5.2 Framework Implementation to Characterize KMS categories

This section presents a framework implementation, in order to characterize the KMS categories reviewed in this paper. The framework describes the major knowledge processes supported, knowledge conversion flows and IC components measured for each KMS category. Table 4 shows the framework implementation.

Table 4 – The Framework for Characterizing KMS: its usage

KMS Categories	KM Processes				Knowledge Conversion Flows				IC Components Measured		
	Creation	Storage & retrieval	Transfer	Application	Combination	Internalization	Socialization	Externalization	Human capital	Structural Capital	Relationship Capital
Document management systems		X	X		X			X			
Knowledge maps	X	X			X	X					
Collaboration systems	X	X	X	X			X	X			
Workflow systems			X					X			
Business intelligence	X				X						
Expert systems			X	X		X	X	X			
Competence management		X			X			X	X		
E-learning systems		X	X			X	X				
Customer relationship management		X	X		X	X		X			X
Corporate portals	X	X	X	X	X	X	X	X			

The framework was populated based on the KMS review that allows to identify the main characteristics of each KMS category, as described below (Ruggles 1997; Baroni 2000; Queen's 2000; European KM 2001; Kakabadse 2003; Lindvall, Rus et al. 2003; CEN 2004):

5.2.1 Document management systems

Document management systems allow knowledge, often dispersed among a variety of retention supports, to be effectively stored and made accessible. They lead only with explicit knowledge and enable explicit-to-explicit conversion. One can argue that a tacit-to-explicit conversion may occur when an employee writes a document or a report. In the KMS literature reviewed, no indicators are specified to measure IC components.

5.2.2 Knowledge maps

Knowledge maps provide the knowledge representation and facilitate the retrieval of organizational knowledge. In this perspective, they support mostly storage and retrieval knowledge process. These tools may also allow users to discover new relationships among knowledge, facilitating the generation of new knowledge. The main knowledge conversion supported by these tools is explicit-to-explicit conversion, because they take the explicit knowledge stored in repositories and turn it into another explicit form, based on the taxonomies adopted. They also support explicit to tacit conversion when the knowledge map built by these tools help to better understand and internalize the knowledge. In the KMS literature reviewed, no indicators are specified to measure IC components.

5.2.3 Collaboration systems

Collaboration systems can support teamwork and thereby increase an individual's contact with other individuals. Often, employees need to communicate and collaborate with each other, especially when they work in a distributed environment. Collaboration can enable and improve knowledge transfer, facilitate knowledge application, and can accelerate the growth of knowledge creation. Some collaborative systems have functionalities to capture and analyse dialogs between people. In this perspective, they also support knowledge storage and retrieval. The main knowledge conversion supported by these tools is tacit-to-tacit conversion, which occurs when people establish synchronous or asynchronous conversation. A tacit to explicit conversion may also occur when people write the conversation in an electronic format or when the system captures the dialogs in order to publish them. In the KMS literature reviewed, no indicators are specified to measure IC components.

5.2.4 Workflow systems

Workflow systems support communication, coordination and collaboration across the organization. Based on the ability to capture and use knowledge about business processes, workflow helps organizations to define, integrate, execute and monitor their business processes. They support mainly knowledge transfer across the business processes. These systems support mainly tacit-to-explicit conversion, which occurs when people define and configure business processes, adding knowledge to them. In the KMS literature reviewed, no indicators are specified to measure IC components.

5.2.5 Business intelligence

The goal of business intelligence tools is to combine different sources of knowledge, identifying new relationships and generating new knowledge. In this perspective, the role of these tools is to support knowledge creation processes by combining existing explicit knowledge structured and unstructured. The discovery process leads with explicit knowledge and creates new explicit knowledge. In this perspective these tools support explicit-to-explicit conversion. In the KMS literature reviewed, no indicators are specified to measure IC components.

5.2.6 Expert systems

Expert systems provide knowledge transfer from experts to other users. Common features on these tools are expert's identification, communication and collaboration between people and experts. Some of those systems capture questions from users and answers from experts, storing them in the knowledge base. These tools enable knowledge application in new situations, through conversation between people and experts, i.e., based on tacit to tacit knowledge conversion. One can argue that explicit to tacit conversion occurs when users can access to FAQ or another explicit knowledge from experts. On the other hand, tacit to explicit conversion may occur when conversations with experts are captured and stored in the knowledge base. In the KMS literature reviewed, no indicators are specified to measure IC components.

5.2.7 Competence management systems

Organizations need to identify and represent their core competences. Competence management systems provide representation and retrieval to organizational knowledge related to human competences, through competence maps, for example. These tools lead with explicit knowledge, supporting mostly explicit to explicit conversion. They are based on repositories and people profiles, and turn it in another form of explicit knowledge – the competence maps. Tacit to explicit conversion may take place when employees create profiles about their own knowledge, skills and competences. Some competence management systems specify indicators to measure human capital, including indices like employees satisfaction, time spent in training, specialized employees, etc.

5.2.8 E-learning systems

E-learning includes computer-based and on-line training, offering interaction between students and tutors. Knowledge can be distributed and transferred through on-line training programs. E-learning systems often include collaboration tools that support knowledge transfer between students and tutors. E-learning also implies storage and retrieval mechanisms for different types of content, like audio, video, documents, etc. These systems support mainly explicit to tacit knowledge conversion when students learn and internalize the explicit contents. A tacit to tacit conversion may occur when people communicate with each other using collaboration and conversation facilities. In the KMS literature reviewed, no indicators are specified to measure IC components.

5.2.9 Customer relationship management

Customer relationship management systems include self-desk (customers in helping themselves through knowledge repositories) and help-desk (personalized support to customers) functionalities. Help-desk includes features that automatically direct customer requests to specialized support, based on communication channels. So, they support knowledge transfer between the company and their customers. When conversion takes place between company support people and customers based on e-mail messages, for example, both tacit to explicit and explicit to tacit conversions occur. The first occur when people write messages exposing problems, solutions, recommendations or suggestions. The second occur when people learn and internalize these conversations.

Self-desk is based on the access to knowledge repositories, like FAQ, for example. In this perspective these tools support storage and retrieval processes. When customers search for knowledge, an explicit to tacit or explicit to explicit knowledge conversion occurs. Explicit to explicit may occur when customers download manual, reports, or other materials; explicit to tacit may occur when customers learn and assimilate knowledge from explicit contents. Some customer relationship management systems specify indicators to measure customer capital, including indices like customer satisfaction, market share, customers lost, new costumers, sales growth etc.

5.2.10 Corporative portals

Corporative portals often create a single access point to different applications and tools that use different information sources. These sources are integrated and accessed through a common but personalized interface – a corporative portal. These systems frequently include functionalities related with knowledge discovery, facilitating the generation of new knowledge. On the other hand, corporative portals with search and retrieval advanced mechanisms increases the speed at which knowledge may be accessed. A corporative portal also contains, frequently, groupware and workflow functionalities, so it supports knowledge transfer. It can provide organizational knowledge at any time anywhere. From this perspective, it facilitates knowledge usage and application. These tools support mainly explicit to explicit conversion. They provide a single and integrated interface, combining different sources and displaying it in an integrated and coherent way. However, if we consider the different tools that can be integrated with an portal, like collaborative systems, workflow, business intelligence, expert systems and others, one can argue that corporative portals support all the knowledge conversion cycles. In the KMS literature reviewed, no indicators are specified to measure IC components.

6. Conclusion

A descriptive framework for characterizing KMS was developed which illustrates the role of KMS in supporting knowledge processes, knowledge conversion flows and IC measurement components. The framework helps organizations to characterize KMS enabling the classification and systematization of KMS capabilities, and helping the selection of appropriate tools according the organization strategy and needs.

From the framework implementation and the identification of the main characteristics of each KMS categories, one can argue that only the competence management and customer relationship management systems specify indicators to measure IC components, respectively, human capital and relationship capital. However, almost all KMS categories may contribute to measure one or more IC components. For example, document management systems can contribute to measure structural capital, through the specification of indicators that evaluate the quality, the availability and the usage of knowledge repositories; workflow systems may specify indicators to measure structural capital, like business processes specification, efficiency and coordination; expert systems may contribute to measure human and structural capital through the specification of indicators that evaluate, for instance, expert skills, expert identification and capacity to capture questions from users and answers from experts.

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