Why To Research in Knowledge Management in Software Engineering Processes?

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Abstract – Knowledge Management is a young discipline that nowadays it is important for software development organizations (SDO). For this reason, this paper presents a review about the form knowledge management has been included in several Software Process Reference Models. For this study, five software process reference models, broadly used in Latin-American countries, were analyzed. The findings of this study show that in all models there are elements of knowledge management processes, and there are two models with a process area named Knowledge Management. Nevertheless, the knowledge management aspects included in these models is grounded in statements from Earl’s systems and engineering schools. Likewise, in terms of Gold’s knowledge management capabilities, the technology, knowledge acquisition and knowledge conversion capabilities are broadly covered but elements for others capabilities are not included in these reference models.

Keywords: Knowledge management in software engineering, Knowledge management processes, Software process reference models, Knowledge management in software organizations.

1 Introduction

In recent years, Knowledge Management (KM) has become an important set of processes in Software Engineering (SE). Several publications have developed this topic from diverse perspectives. One synthesis of the scientific work about KM in SE [1] identified the predominant interest in topics such as knowledge codification, IT-based knowledge storage and retrieval. However, knowledge creation, knowledge transfer and knowledge application are processes that have had little coverage. Furthermore, the authors concluded that most of the empirical research works are focus on KM in software process improvement (SPI).

In this regard, KM in software processes and KM in SPI were identified by [2] as important research topics, because KM is the main component of SPI initiatives. Also, the application of KM in SE is useful in software process definition, the application of a process approach in software engineering, and the adaptation of software process for future uses. However, in a deeper review of papers in which the main topic is KM in SPI, published in the last five years, we found out that the predominant approach is knowledge codification, as can be seen in [3]–[9]. In addition, there are works about knowledge mapping by the construction of organizational knowledge directories [5], [10] and the creation and empowerment of organizational structures to promote knowledge sharing [10]–[13].

After the review we identified that the research on KM in SPI has been focused in the application of KM as a tool in SPI initiatives. However, KM does not be conceived as an integral process within the scope of SPI. For that reason, the purpose of this paper is to present a review about how KM has been included in several SPRM. It is important to say that the SPRM are the basis for SPI initiatives because they contain the process definitions that a SDO could implement and improve to gain process capability and organizational maturity.

The remainder of this paper is organized as follows. Section 2 presents the theoretical background about KM. Section 3 describes the methodology used for the review. Section 4 presents the results of the review according to our chosen theoretical background. Section 5 concludes.

2 Theoretical Background

This section presents a synthesis of two theoretical statements needed for the later analysis of the selected SPRM. In the first part, a classification of KM work into schools of thought that was proposed by [14] is presented. In the second part, a complementary perspective, composed by a set of KM organizational capabilities, proposed by Gold, Malhotra and Segars [15], is described.

The first referent is a “KM strategies taxonomy” proposed by Earl in 2001 [14]. The used methodology and the variety of data sources make this classification one of the most detailed. Further classifications can find in [16]–[24], but Earl’s taxonomy is considered the most complete, because It was constructed based on descriptive data from: (1) six case studies in companies; (2) interviews with 20 chief knowledge officers; (3) Workshops about KM programs in organizations; and (4) a review of publications about KM from research and practice. The identified KM schools are categorized as “Technocratic”, “Economic” and “Behavioral”.
The technocratic schools are focused on IT tools to support employees in their knowledge-based tasks. The technocratic schools are the systems school, the cartographic school and the engineering school. The systems school is focused on technology for knowledge codification and sharing using knowledge bases. The cartographic school is focused on the creation and maintenance of knowledge maps using knowledge directories. The engineering school is focused on knowledge processes and knowledge flows within organizations.

The economic schools are focused on the exploitation of knowledge as intellectual capital to create revenues streams. In the economic schools Earl identified only the commercial school.

The behavioral schools are focused on the promotion and encouragement of knowledge creation and sharing and all organizational and personal issues to use knowledge as an organizational resource. In the last category there are three schools identified as organizational school, spatial school and strategic school. The organizational school is focused on the creation of networks for sharing knowledge. The spatial school is focused on the design of work spaces to promote knowledge sharing. The strategic school is focused on the development of the organizational strategy based on knowledge as its essence. A synthesis of Earl’s taxonomy is showed in Table 1.

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<tr>
<th>Category</th>
<th>School</th>
<th>Focus</th>
<th>Aim</th>
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<tbody>
<tr>
<td>Technocratic</td>
<td>Systems</td>
<td>Technology</td>
<td>Knowledge bases</td>
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<td></td>
<td>Cartographic</td>
<td>Maps</td>
<td>Knowledge directories</td>
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<td></td>
<td>Engineering</td>
<td>Processes</td>
<td>Knowledge flows</td>
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<td>Economic</td>
<td>Commercial</td>
<td>Income</td>
<td>Knowledge assets</td>
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<td>Behavioral</td>
<td>Organizational</td>
<td>Networks</td>
<td>Knowledge Pooling</td>
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<td></td>
<td>Spatial</td>
<td>Space</td>
<td>Knowledge exchange</td>
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<td></td>
<td>Strategic</td>
<td>Mindset</td>
<td>Knowledge Capabilities</td>
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The second referent is the work of Gold, Malhotra and Segars that was published in 2001 [15]. In this work, the authors argue that organizations must leverage their knowledge and create new knowledge to compete in their markets. In order to accomplish this, organizations must develop two types of KM capabilities: knowledge infrastructure capabilities and knowledge process capabilities. Knowledge infrastructure capabilities enable maximization of social capital, understood as “the sum of actual and potential resources embedded within, available through, and derived from the network of relationships possessed by a social unit” [15]. Complementary, knowledge process capabilities are the dynamic elements that leverage the infrastructure capabilities to make knowledge an active organizational resource.

The three infrastructure capabilities are technology, structure and culture. The technological dimension addresses the tools and means that enable knowledge flows in an efficient way.

The structural infrastructure focuses on the existence of norms, and trust mechanisms, as well as, formal organizational structures, which enable and encourage people to create and share knowledge. The cultural dimension refers to the presence of shared contexts within organization.

The four process capabilities are knowledge acquisition, knowledge conversion, knowledge application, and knowledge protection. The knowledge acquisition process is oriented toward obtaining knowledge from diverse sources both within and outside organizations. The knowledge conversion process is focused on making existing knowledge useful based on knowledge encoding, combination, coordination and distribution. The knowledge application process is oriented toward the actual use of knowledge, and the knowledge protection process is designed to protect the organizational knowledge from illegal or inappropriate use or theft. As illustrated in Figure 1, in terms of Gold et al, infrastructure and process dimensions reflect an additive capability to launch and sustain a program of change through KM in order to gain organizational effectiveness.

![Knowledge management capabilities and organizational effectiveness.][15]

3 Methodology

The methodology designed for this work consists of three stages:

1. **SPRM selection**: The purpose of this stage was to select a set of SPRM used at Colombian and Latin American levels. To do this, a set of publications of the last decade, which main topic was SPI in Latin America’s SDO were reviewed. The five most mentioned SPRM were selected.

2. **Analysis of SPRM Processes and KM**: The description of each process within each SPRM was analyzed to find aspects related to KM. The review was focused on the statement of process purpose and the descriptions of process outcomes. A subset of KM-related processes was selected.
3. **Mapping of SPRM process and KM:** In this stage, the KM-related processes selected in the second stage were analyzed in relation to the KM schools proposed by [14] and the organizational KM capabilities, proposed by [15]. To do this, a single mention of some idea from KM schools or KM capabilities, was enough to map the process.

### 4 Results

The main results of this work were: 1) the selection of five SPRM; 2) the identification of 19 processes related to KM within SPRM; and 3) the mapping of the 19 processes to KM schools and KM organizational capabilities. In the next three subsections the detailed results of each stage are described.

#### 4.1 SPRM selection

The first result was the selection of five SPRM from a set of 155 documents from SCOPUS database. The selected models were: 1) the ISO/IEC 122007 standard; 2) the Capability Maturity Model Integration for Development (CMMI-DEV); 3) the Brazilian SPRM (MPS.BR, acronym of the Portuguese expression “Melhoria de Processo do Software Brasileiro” or Brazilian Software Process Improvement); 4) the Mexican Software Industry Process Model (MoProSoft, acronym of the Spanish expression “Modelo de Procesos para la Industria del Software”); and 5) the SPRM from the program “Process Improvement for Promoting Iberoamerican Software Small and Medium Enterprises Competitiveness” (Competisoft). All these models were developed in collaborative works between the software industry and academic institutions. Also, they have been developed under the general structure defined in ISO/IEC 15504 standard [25]–[27]. In Table 3, the selected SPRM are described.

#### 4.2 Analysis of SPRM Processes and KM:

The analysis of the processes to identify those with some KM ideas resulted in a set of 19 processes from the 101 processes included in the five selected models. In Table 2, the selected processes, for each SPRM, are presented.

#### 4.3 Mapping of SPRM process and KM

Related to the analysis of SPRM and KM schools, we found out that most of the KM aspects are related to systems school. In other words, the predominant approach is knowledge codification. In fact, even in several SPRM there is an explicit reference to KM or to organizational knowledge (MoProSoft, Competisoft), the scope of this process is limited to keep available and manage a knowledge repository. The content of this knowledge repository is, mainly, best practices, lessons learned, knowledge work products, and knowledge about process definitions. Also, ISO/IEC 12207, CMMI-DEV and MPS.BR included the concept of an organizational knowledge repository as part of two processes: configuration management process and organizational process definition process.

In addition, all SPRM include aspects related to engineering school. In particular, this school appears in the form of training activities and the provision of qualified personnel to do knowledge activities. These statements are part of human resource management processes. In Table 4, the relations between the selected SPRM and the KM schools are presented.

<table>
<thead>
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<th>Table 2 Processes related to KM ideas.</th>
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<td><strong>Model</strong></td>
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<td>ISO 12207</td>
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<td>CMMI-DEV</td>
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<th>Table 3 Description of selected SPRM.</th>
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<td><strong>Model</strong></td>
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<td>CMMI-DEV</td>
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<td>Competisoft</td>
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In terms of the organizational KM capabilities, the studied SPRM do not include explicitly the cultural knowledge management capability. Nevertheless, in recent years the research literature in software engineering process design and improvement, especially all “agile” movement, has emphasized the crucial role of organizational culture in SDO. For this reason, this absence is a big gap to fill soon. Moreover, the studied SPRM do not include two crucial process capabilities: knowledge application and knowledge protection.

Along these lines, this work has showed that the studied SPRM include, within their scope, some aspects related to KM. This fact reaffirms the importance of KM for SDO, and, in particular, the importance of KM in SPI. Mainly, the topics of interest about KM in SPRM are: 1) knowledge codification, 2) use of knowledge repositories, and 3) organizational training. These interest topics are located, in terms of Buono and Poulfelt [49], in a first generation KM. In this type of KM, knowledge is considered as a possession or something that could be caught and stored in IT-based knowledge repositories. On contrary, in the second generation KM, knowledge is considered a complex phenomenon concerning to socio-cultural, politic and technological aspects. Hence, a gap is evidenced in the content of the analyzed SPRM because they do not take into account elements from the second generation KM.

These arguments allow us to formulate three questions that serve as a source of motivation for future research: 1) what KM outcomes and purposes should be included in the existing SPRM to have a more complete reference in processes design, implementation, evaluation and improvement within a SDO?; 2) is it possible to incorporate the KM purposes and outcomes
as a new KM process within existing SPRM? Or, maybe is it necessary a KM process reference model for SDO?; 3) if the resultant KM process reference model would be used in an process capability determination initiative, how could be the correspondent KM process evaluation model?. The answers of all these questions have high value in KM research and would constitute a contribution aligned to the KM research trends identified by [50]. They argue that future research in the field of KM requires studies related to unifying different KM models in the existing literature and understanding the determinants of the evolution of KM in organizations. Also, studies pertaining to KM effectiveness and associated organizational and IT support are needed.

Summing up, this work constitutes an important reference for research and practice because it presents a synthesis of the knowledge management topics included in software process reference models, and helps practitioners, from software development organization, to identify the foundations and the options to implement knowledge management initiatives within their organizations. Likewise, this study helps researchers to identify trends and topics to formulate new research projects about include the different “flavors” of knowledge management in software process reference models or to develop a knowledge management process reference model relevant for software development organizations.

### 6 References


