MODELING KNOWLEDGE FLOWS IN SOFTWARE PROJECT MANAGEMENT PROCESSES

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Abstract: Software development SMEs interested in launching a KM initiative or software project managers working on taking their KM initiative to the next level, need to assess what strategy will best fit their knowledge needs and which will be the most likely to succeed based on their social, cultural and technological aspects. Taking into account the social and cultural characteristics of Mexican software development SMEs, the Mexican Ministry of the Economy encouraged the creation and adoption of the NMX-I-059-NYCE-2005 Standard. The main goal of this standard is help SMEs become more competitive and reach higher maturity levels. However, SMEs adopting or implementing this standard sometimes experience difficulties and problems in their daily software activities. In this paper, we model ongoing knowledge flows as an adaptation to Choo's framework, applied to the project portfolio management process as defined in such standard. In addition, we present some strategies followed by Mexican software development SMEs while conducting a SPI program for maturity levels 1 and 2.

1 INTRODUCTION

The organizations' capability to learn and innovate depends on their ability to manage and integrate a complex network of processes in which participants enact and negotiate their own meanings of what is going on; stumble upon and engage with new knowledge to make it work; and work within as well as improvise around set rules and routines to solve tough problems (Choo and Johnston, 2004). Knowledge Management (KM) can help address this issue, since it provides methods, techniques and tools for facilitating organizations to become adaptable to these changing environments (Davenport and Prusak, 2000).

Currently, the KM implementation strategies of Small and Medium Enterprises (SMEs) are based on the knowledge residing among the knowledge workers (Wong, 2005), such as project managers or developers. They apply a combination of several types of knowledge and abilities with the aim to accomplish their goals.

In order to provide support to the knowledge flow within software development SMEs, it is important to identify specific issues of the dynamics of knowledge flows in the processes and activities performed by members of these organizations; as well as the social, cultural, and technological aspects which can affect those flows (Rodríguez-Elías, Vizcaíno, Martínez García, Favela and Piattini, 2009). Besides this, other approaches can be used for establishing a general profile of knowledge needs within a Software Process Improvement (SPI) program, supporting the design implementation and use of the SME's knowledge base or experience base.

SPI initiatives often experience difficulties and problems when the improvements are implemented and institutionalized in the organization's daily practices. Sometimes SPI programs experience severe problems and some even fail after the

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assessment, when improvements must be implemented and institutionalized in the organization's daily software activities, and there is a need for more guidance on how to implement and institutionalize SPI (Arent and Nørbjerg, 2000). Oktaba, Piattini, Pino, Orozco y Alquicira (2008) conducted a systemic survey on SPI. They found that most SPI initiatives (71%) deal with guidance of an improvement project, prioritizing improvements implementation and using current improvement models. In addition, use of KM in SPI initiatives accounted for 11% of the cases. Capote, Llanten Astaiza, Pardo Calvache, González Ramírez y Collazos (2008) state that process improvement models, such as IDEAL (McFeeley, 1996), lack a management mechanism, for both tangible and intangible assets, that eases capture and use of valuable experiences during the performance of improvement cycles. IDEAL is a process improvement model that provides a structured approach for continuous improvement based on experiences from large organizations. Therefore, it had to be adjusted for use in SMEs (Casey and Richardson, 2002).

The motives listed above form a base for our research. We are interested in analyzing ongoing knowledge flows applied to the key principles of KM-based SPI initiative using the Mexican Standard NMX-I-059-NYCE-2005. In this perspective, it is important to identify specific issues of the dynamics of knowledge flows in the processes and activities performed by the members of the organization (Rodríguez-Elías et al., 2009).

2 SOFTWARE PROJECT MANAGEMENT PROCESSES IN THE NMX-I-059-NYCE-2005 STANDARD

NMX-I-059-NYCE-2005 is a Mexican Standard developed to assist Mexican SMEs in an SPI program implementation. This standard borrows practices from other process improvement models, such as CMMI v1.1, Project Management Body of Knowledge (PMBOK), the Software Engineering Body of Knowledge (SWEBOK) and uses ISO 9001 as a general framework. It is divided into four parts and complements the current Mexican Standards NMX-I-006-NYCE (parts 01, 02 and 03) and NMX-I-045-NYCE. Part 04 of the NMX-I-059-NYCE-2005: Guidelines for Processes Assessment, is based on the ISO/IEC 15504-2:1998. The process assessment model defines five levels of capability and their associated attributes.

Part 01 of the NMX-I-059-NYCE-2005 presents the 9 required processes, grouped into three process categories presented by means of a Unified Modeling Language package diagram (NMX, 2005). The management Category consists of management practices for process management, projects portfolio and resource-management based on the guidelines established by the Top Management category. Operations category addresses the practices of software development and maintenance projects (NMX, 2005). Each process identifies the roles involved, required training, and infrastructure resources needed to support activities. Here, the term infrastructure is defined as a set of elements or services deemed necessary for the creation and operation of an SME (NMX, 2005).

Even though this standard recognizes knowledge and training as strategic resources, it only specifies general training profiles for roles. As a result, the relationship between software project management profiles, the process capacity level and its associated attributes, remains undefined.

In addition, the Mexican standard suggests storing organizational knowledge, e.g., Lessons Learned (LL) and work experiences, in a knowledge base; facilitating SMEs to learn from their accumulated knowledge. This would help decrease reworking, as well as reduce the appearance of recurring problems, allowing Mexican software development SMEs become more competitive (Oktaba et al., 2008) and reach higher maturity levels. The maturity levels are described as a number of generic software development and management practices. Arent and Nørbjerg, (2000) suggested including KM practices in the maturity models. Software process maturity is defined as the extent to which a specific process is explicitly defined, managed, measured, controlled and effective.

3 RESEARCH APPROACH

The research approach is organized as qualitative methodology to guide the process of identifying the ways knowledge flows in an organization, by modeling them using a Process Reengineering approach. This methodology is named as KoFI and is composed by three stages (Rodriguez-Elias et al., 2009).

The first stage deals with modeling the process based on the flows of knowledge, including the activities performed by the members of the

organization, the knowledge required and generated in the activities, the people in charge of them, and the sources of knowledge used, modified, or generated during the activities. Analysis of the process is performed in stage 2, while stage 3 is oriented to identify the infrastructure resources or tools that get involved with the flows of knowledge (Rodríguez-Elías, 2007).

3.1 Knowledge Flows Modeling for Software Project Management

Software project management is defined as a discipline which uses knowledge and skills to fulfill the goals of a project by means of the execution of a set of activities. Two of the nine processes defined in the Mexican Standard, Project Portfolio Management process (GPY) and Specific Projects Management process (APE), are related to software project management. The purpose of GPY is to ensure that projects contribute to fulfilling the organization's goals and strategies. On the other hand, APE applies knowledge, skills, techniques and tools to each one of the following project activities: planning, performance, evaluation and control and closing. NMX-I-059-NYCE-2005 Standard project management related roles are Project Portfolio Manager (RGPY) and Specific Projects Manager (RAPE) (NMX, 2005).

A process modeling approach can be very useful to identify how the knowledge and resources of information are involved in the activities developed by members of the organization. A Rich Picture Diagram (RPD), as a graphical modeling technique, can be used to analyze how the knowledge flows through the group while its members perform their activities (Rodríguez-Elias et al., 2009).

Based on the first stage of the KoFI methodology, we made an adaptation of Choo's framework of the knowing organization using a RPD with elements introduced by Rodriguez-Elias (Figure 1). Knowing organization model is useful to identify and analyze the structure and dynamics of key processes (Choo and Johnston, 2004).

Information flows are continuously moving between sensemaking, knowledge creation and decision making; so the outcome of information use in one mode, provides the elaborated context and the expanded resources for information use in other processes (Choo and Johnston, 2004).

Figure 1 shows the main tasks carried out in the performance activity of the GPY, as defined in the NMX-I-059-NYCE-2005 Standard. In this model, a *knowledge worker*, represented by the RGPY, creates and transfers knowledge using the SECI model (Nonaka and Takeuchi, 1995). *Socialization* is attained when the RGPY transfers and acquires tacit knowledge to and from the RAPE and the members of the software development team. *Externalization* occurs through dialog that leads to articulation of tacit knowledge and its subsequent formalization to make it concrete and explicit. *Combination* denotes coordination between different groups in the project, along with documentation or existing knowledge, to combine new explicit knowledge in the software SME.

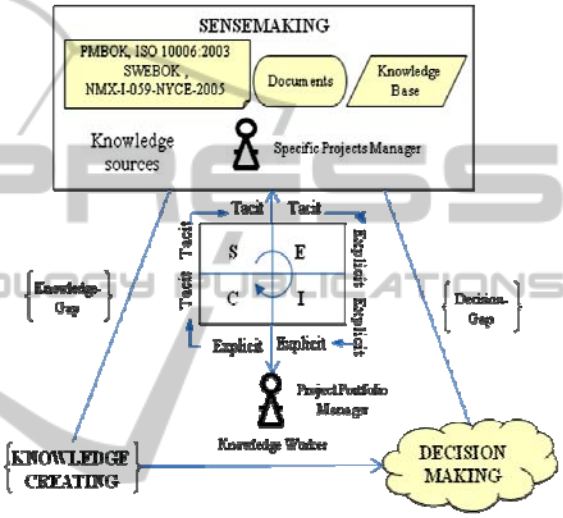

Figure 1: Adaptation of Choo's model using a RPD.

Sensemaking allows the RGPY to construct tacit knowledge from explicit knowledge (*Internalization*) by sharing meanings and information that shape the organization's purpose and frame the perception of problems or opportunities that the organization needs to work on. The *knowledge sources* can be people, documents, support tools and internal products developed by the software organization (Rodríguez-Elías et al., 2009). Mexican software development SMEs can use PMBOK, SWEBOK, ISO 10006:2003 or NMX-I-059-NYCE-2005 as reference documents (Declarative-Topic Knowledge) for identifying useful information on topics like time and cost estimation or project descriptions generation. RPGY and RAPE store documents in the knowledge base or remember the products of successful sensemaking as stories, LL or causal sequences so that they are available for future sensemaking.

Knowledge creation is precipitated by gaps in the existing knowledge of the software organization or a project group. The outcome of knowledge creation is

a set of new abilities, capabilities, innovations (Knowing-Doing Gap) or new products and services. Such *knowledge gaps* stand in the way of solving a technical or task-related problem (Declarative-Episodic Knowledge), developing a new product, or taking advantage of an opportunity (Choo and Johnston, 2004).

The difficulty of making a decision then depends on how clear project goals are, and how well the RGPY knows about alternatives that lead to achieve those goals. The RGPY and the software development team may find that they lack the knowledge or capability to solve the problem or exploit the opportunity, which is known as a *decision-gap*.

In addition, we identified two of the five perspectives of Alavi and Leidner (2001) embodied in the model. If knowledge is a process then the implied KM focus is on the knowledge flow and the processes of creation, sharing and distribution of knowledge. Otherwise, the view of knowledge as a capability suggests a KM perspective centered on building core competencies and creating intellectual capital. The capability to use information and tacit knowledge (LL and experience) results in an ability to interpret information and to ascertain what information is necessary in decision making.

In order to identify the experience acquired by a SME while conducting a SPI program for maturity levels 1 and 2, we arranged reflection meetings with three software development SMEs located in the state of Baja California, México that have been verified by NYCE, as the Mexico's official certifying organization. The SMEs didn't have a rough idea about how to integrate SPI from the KM perspective. They only expressed the experiences generated in their SPI program.

The analysis of the empirical data revealed that 66% of the SMEs decided to implement their own knowledge base using the requirements of the Mexican Standard as their only reference. This Standard was also the only knowledge source for the implementation of the SPI program used by all the SMEs. Additionally, they were supported in different ways by expert networks. Social processes and expert networks (consultants) are necessary because their tacit knowledge must be transmitted to the SPI team. Also, we detected the importance of knowledge sharing to equip the software development group with the skills to foster creativity and innovation. Accordingly, KM-based SPI program are quite people intensive, although a knowledge base or experience base were helpful for SMEs to improve their required processes (top management, management and operation) and technical infrastructure to reach capability level 2.

4 CONCLUSIONS

The adapted model presented in this paper integrates Choo's model, SECI model and several types of knowledge, because we considered they are approaches related to knowledge flows. Choo's model considers knowledge flow as part of an organizational context, seeing it as an enabling resource for using information with practical goals, such as decision making. In contrast, the knowledge creation process approach relies on the four modes of spiraling SECI.

Once the knowledge needs of empirical study's software project managers are identified, they will help in the characterization of a KM level-specific profile for GPY and APE processes, required by the NMX-I-059-NYCE-2005 Standard. This profile can help a software project manager identify training needs within a SPI program, supporting the design implementation and use of the SME's knowledge base.

We are currently conducting a study aimed to find out the correlation between the KM level and the capability level defined in the 2nd part of the NMX-I-059-NYCE-2005 Standard. Here, we have presented the preliminary results of the first step towards the identification of such correlation.

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