Research on CMM-based Knowledge Management Maturity Models

Brenda L. Flores Rios[1], Oscar Mario Rodríguez-Elias[2], Francisco J. Pino[3]
[1] *Institute of Engineering, Autonomous University of Baja California*
[2] *Division of Graduate Studies and Research, Institute of Technology of Hermosillo*
[3] *Electronic and Telecommunications Engineering Faculty, University of Cauca*
[1]*brenda.flores@uabc.edu.mx* [2]*omrodriguez@ith.mx* [3]*fjpino@unicauca.edu.co*

Abstract

To describe the progress of Knowledge Management strategies in organizations, various Knowledge Management Maturity Models (KMMMs) have been proposed and developed. From the context of Software Process Improvement (SPI), two categories are identified: Non-CMM-based KMMMs and CMM-based KMMMs. This paper describes the literature review of a state of the art analysis for CMM-based KMMMs, based on the premise that SPI can be considered as an instance of Knowledge Management. Findings indicate that CMM-based KMMMs and their knowledge areas can serve as useful components to evaluate KM maturity in KM-based SPI projects.

1. Introduction

Essentially, maturity models describe the development of an entity over time. This entity can be anything of interest such as an organization function [1], a product, process or technology. From a Software Process Improvement (SPI) perspective, the maturity models describe software process capability in terms of a hierarchy of maturity levels, where each higher level corresponds to improved capability [2].

Even though maturity modeling as a technique has its inherent advantages and limitations, it seems to be promising to apply it to the field of Knowledge Management (KM) [1]. KM refers to the process of identifying and leveraging the collective knowledge in an organization to help the organization compete [3, 4]. Currently, the KM implementation strategies of Small and Medium Enterprises (SMEs) are based on the knowledge residing among the knowledge workers [5], such as project managers or software developers. Hence, the maturity models can be seen to embody knowledge about good software practice, and where to focus improvement initiatives given the current status of an organization [2].

In recent years, researchers and practitioners have proposed maturity modeling as a way of formally capturing the KM development process by assessing the extent to which KM is explicitly defined, managed, controlled, and optimized [6]. As a result, there is a growing number of Knowledge Management Maturity Models (KMMMs). KMMM can be considered as an application of structured approach to KM implementation [7]. KMMM are categorized into two groups, depending on whether or not their development is based on the Capability Maturity Model (CMM®) or its latest version Capability Maturity Model Integration (CMMI®) [8]. As one of the most widely used models [9], CMM focuses on the standardization of the software production process, which provides a standard to evaluate the maturity of software organizations [10].

The NMX-I-059-NYCE-2005 Mexican standard was developed considering integration between software processes and business processes. It borrows practices from other standards, covering 92% of ISO 9001:2000, 95% of ISO/IEC 12207 and 77% of CMMI Level 2 [11]. The standard identifies one knowledge-oriented process (named Organization's Knowledge) and a knowledge base as a repository for 70 work products, software configuration, technological knowledge, and lessons learned for its 9 processes [12]. Even though this Mexican standard recognizes knowledge and training as strategic resources, it only specifies general KM activities and training profiles for roles. As a result, the relationship between software project management profiles, the process capability level and its associated attributes, remains undefined [13]. By the above, we believe that it is important to work on how to establish knowledge maturity level concepts for KM tailored to the knowledge needs of Mexican software development SMEs which help them improve the maturity level of their required processes.

The purpose of this paper is to provide an overview on the state of the art for KMMM and the source models from which they have been developed, specifically CMM. The process of literature review was based on [14]. This comprises: 1) the querying of scholar databases using keywords and 2) forward searches on the basis of relevant articles.

The research questions we focused on were: Which KMMMs are been developed? What are the characteristics of maturity levels defined for each one, especially CMM-based KMMMs? Could an existing CMM-based KMMM be adopted as a basic element for implementing KM-based SPI projects based on the NMX-I-059-NYCE-2005 Mexican standard?

In this paper, we present the results of a literature review on maturity models for KM, organized within the concept of maturity levels, capability process and/or knowledge maturity levels, which could be suitable for implementing or assessing KM strategies in an SPI project within software development SMEs.

2. Process improvement according to CMMI

In its aim to help organizations develop and maintain quality products and services, the Software Engineering Institute has found three dimensions that organizations can focus on to improve its business: people, procedures and methods, and tools and equipment [15]. In this document we use SPEM-KF symbolism to represent the relationship of the 3 dimensions, which depends on process dimension (Figure 1). SPEM-KF extends SPEM, a UML based metamodel which has been specifically designed for software process modeling, to aid in the identification and analysis of knowledge flows [12]. Figure 1 shows how process dimension allows organizations to address scalability and provide a way to incorporate knowledge and infrastructure to maximize the productivity of people and the use of technology to be competitive.

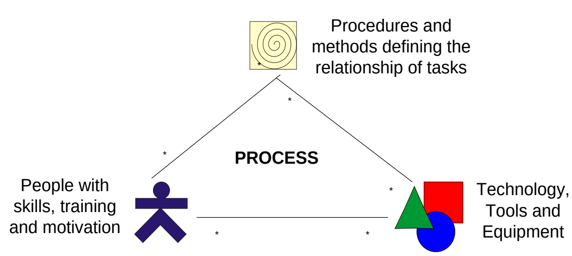

Figure 1. The three dimensions of CMMI v1.3 represented by SPEM-KF

In general, capability maturity models contain the essential elements of effective processes for one or more disciplines and describe an evolutionary improvement path from ad hoc, immature processes to discipline, mature processes with improved quality [15].

CMM focuses on the improvement of the software development process, and uses effective, organized management and plans to continually improve and enhance the quality of software products [10]. CMMI for Development (CMMI-DEV) model provides guidance for applying best practices in a development organization. CMMI-DEV V1.3 model supports two improvement paths using levels. The levels correspond to continuous and staged approaches to process improvement [15].

The continuous representation uses capability levels to characterize the state of the organization's processes related to an individual Process Area (PA), whereas the staged representation uses maturity levels to characterize the overall state of the organization's process related to the model as a whole (Table 1). CMMI-DEV contains 22 PAs. Five of those PAs focus on practices specific to development, 16 are core PAs and 1 is a shared PA [15]. Definition of each PA is out of the scope of this paper.

Table 1. Levels correspond to continuous and staged approaches to process improvement [15]

Level	Representation	
	Continuous (capability levels)	Staged (maturity levels)
0	Incomplete	
1	Performed	Initial
2	Managed	Managed
3	Defined	Defined
4		Quantitatively Managed
5		Optimizing

We found significant improvements in CMMI-DEV V1.3. Some of them include: high maturity PAs are improved to reflect industry best practices; levels 4 and 5 goals and practices were eliminated as well as capability levels 4 and 5 to appropriately focus high maturity on the achievement of business objectives, which is accomplished by applying capability level 1-3 to the high maturity PAs [15].

Table 1 shows four capability levels numbered 0 through 3, while the five maturity levels are numbered 1 through 5. Capability levels apply to an organization's process improvement achievement in individual PAs. These levels are a mean for incrementally improving the processes corresponding to a given PA. On another note, maturity levels are measured by the achievement of the specific and generic goals associated with each predefined set of PAs [15].

Although CMM was originally proposed to describe software processes, it has been adapted to develop several KMMMs, based on the premise that SPI can be considered as a specific instance of KM and the concepts proposed in CMM may therefore be also appropriate to describe KM [6, 17] maturity levels. Therefore, the framework of the CMM offers the closest resemblance to the KM maturity problem [18].

3. Review of Knowledge Management Maturity Models (KMMMs)

The maturity models have the following properties [1]: a) The development of a single entity is simplified and described with a limited number of maturity levels (usually four or six); b) Levels are characterized by certain requirements which the entity has to achieve on that level; c) Levels are sequentially ordered; and d) During development the entity is progressing forwards from one level to the next.

In recent years, several researchers have reviewed KM maturity problem and proposed various life cycle models commonly known as KMMM [6, 19]. Developing KMMM by conducting design-oriented research means finding solution patterns for important unsolved problems or giving advice in solving problems in more effective or efficient ways [20]. So, an ideal KMMM may be built to measure the level of adherence to a standard set of KM processes [18].

Generally, a literature analysis should be limited to certain period of time. We found that the first KMMM was developed in the year 2000 by Langen [21], including 5 stages and oriented to systematic development of KM structures and non-based directly on processes like CMM. Hain and Back [20] classified 55 maturity models in the area of collaboration, e-learning and KM. Three categories were identified: scientific (academic and researchers), practitioner-oriented scientific (research institutes) and practitioner-based (consulting firms). This classification does not imply an evaluation of the maturity model's quality, but suggests a different focus on KMMM and other disciplines.

In this paper, we are interested on modeling the maturity of KM initiatives. We found that KMMMs can be categorized depending on whether or not they are developed based on CMM concepts [22]. Non-CMM-based maturity models are rather chaotic and leak in an appropriate form or functioning [20]. We detected that CMM model is also known as SW-CMM and the CMMI-DEV model as CMMI. In spite of the name or initial used, in the original KMMM, each set of synonymous names or initials refer to basically the same model.

3.1 CMM-based KMMM

An analysis by Alves and Schneck categorized 28 KMMMs into two groups, depending on whether or not they were developed based on the CMM model. For our analysis, we selected all 6 models from the CMM-based KMMMs group [23]. These models are listed on Table 2.

Table 2. List of CMM-based KMMMs [19]

	Name	Characteristics
1	Infosys KM Maturity Model [25]	- Based on staged representation, but includes different elements from CMM
2	KMMM Intel [18]	- Based on CMM - Describes two types of assessment: Perceptual and Infrastructure
3	KMMM Siemens [24]	- Based directly on staged representation - The assessment methodology described is objective
4	Knowledge Management Capability Assessment Model (KMCA) [23]	- Specifies Maturity Level 0 - Based on staged representation - Specifies the subjective assessment methodology with questions
5	Knowledge Process Quality Model (KPQM) [17]	- Integrates aspects of Quality management and Process Reengineering - Based on staged representation
6	General Knowledge Management Maturity Model (G-KMMM) [26]	- Based on CMM - The assessment methodology is objective

Four of the CMM-based KMMMs are based on the original version of CMM and the staged representation [23]: Siemens' KMMM [24], Infosys' KMMM [25], Knowledge Process Quality Model (KPQM) [17] and Knowledge Management Capability Assessment Model (KMCA) [27].

Even though staged approaches to process improvement do not include a maturity level 0 (Table 1), the KMCA model specifies this level in order to denote complete lack of KM. According to CMM approach, each KM activity belongs to a corresponding management object, a maturity level, and a knowledge area (key area). A knowledge area is a cluster of related KM activities in an area that, when implemented collectively, satisfy a set of goals considered important for improvements in that area [28]. Further discussion on knowledge areas for CMM-based KMMMs is presented on section 4.2.

3.2 Knowledge Management Assessment

The KM maturity level of an organization is obtained through assessing its KM processes. The objective of the survey instrument is to both identify the level of KM maturity for an organization and provide guidance on how to improve that level [18]. However, this assessment is not as straightforward as the assessment of software process capabilities. This is because outcomes of KM are not easily measurement [18]. So, details on how an organization's KM maturity can be assessed and determined remain elusive [6], because their assessment tools are either proprietary or unspecified. Hence, KMMM are ad hoc or have not been empirically tested [18].

Kuriakose *et al.*, [7] defined three types of assessment: subjective, objective and not known. Subjective assessment could be in the sense that the evaluation is purely based on the opinion expressed by various stakeholders. Objective assessment implies that the evaluation involves collection and analysis of evidences to support the opinion expressed by various stakeholders. From the models listed in Table 2, KMCA is validated by empirical methods (Subjective Assessment) [7]. Siemens' KMMM, Infosys' KMMM and G-KMMM models have provided some details about their objective assessment. Though the KPQM model discusses the assessment globally, it does not clearly specify the methodology [7]. Therefore, this model is in the not known group.

4. Analysis

We found that CMM-based KMMMs shown in Table 2 adopt diverse concepts and are based on different assumptions. For example, Infosys' KMMM includes many different elements from CMM. Its maturity levels are named [26]: 1) Default, 2) Reactive, 3) Aware, 4) Convinced and 5) Sharing.

This makes their comparison, selection and application difficult for both researchers and practitioners. However, all five CMM-based KMMMs presented in Table 3 have similar structure. In this table, five maturity levels of CMM are shown: initial, repeatable, defined, managed and optimizing. Previously, Table 1 presented maturity levels described by CMMI v1.3.

The degree of progression in the development and implementation of a KM strategy may be simply explained with a two-dimensional model (Figure 2). It means that a software development organization's knowledge maturity can be represented by several stages.

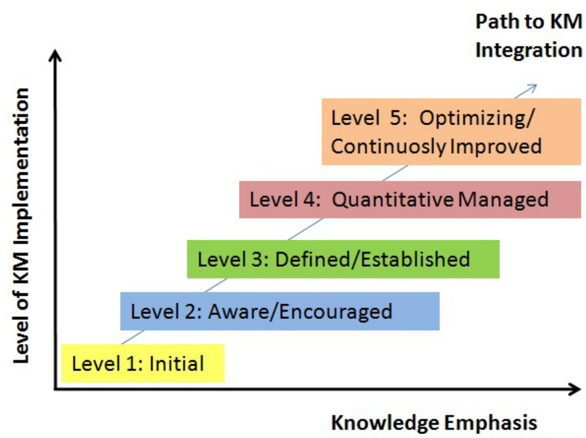

Figure 2. Representation of maturity levels for CMM-based KMMMs

Figure 2 provides a diagrammatic representation of the stages within KMMM. *Y*-axis is used to ascertain the level of KM implementation or maturity and the other pinpoint (*x*-axis) the degree to which implementation is managed. An organization seeking to implement KM will progress through these levels in sequence [29].

Table 3. Naming of maturity levels of CMM-based KMMMs

			CMM-based Knowledge Management Maturity Models			
Level	CMM	CMMI v1.3	Siemens' KMMM	KMMM Intel/ KMCA	KPQM	G-KMMM
0				Lack of KM		
1	Initial	Initial	Initial	Possible	Initial	Initial
2	Repeatable	Managed	Repeatable	Encouraged	Aware	Aware
3	Defined	Defined	Defined	Enabled/Practiced	Established	Defined
4	Managed	Quantitative Managed	Managed	Managed	Quantitative Managed	Managed/Established
5	Optimizing	Optimizing	Optimizing	Continuously Improved	Optimizing	Optimizing/Sharing

4.1 M aturity L evels o f C MM-based K MMM Defined

To obtain a common representation of these maturity levels, we extracted the most relevant features from each model. Next, we present a brief description of each maturity level:

a) *Level 0*. This level represents lack of identification of knowledge assets, knowledge sharing is discouraged and people do not seem to value knowledge sharing. General unwillingness to share knowledge. Only KMCA model defines this level.

b) *Level 1*. The quality of KM processes is not planned and changes randomly. No conscious control of KM processes. People who understand the value of knowledge sharing share their knowledge. Knowledge assets are identified/recognized. Level 1 describes the primary state of KM maturity (Figure 2).

c) *Level 2*. First structures are implemented to ensure a higher process quality. Explicit knowledge assets are stored. Tacit and implicit knowledge are tracked. De Gooijer (2000) [30] emphasizes the importance of awareness as a first step towards maturity. KPQM and G-KMMM models level 2 are called aware instead of managed/repeatable.

d) *Level 3*. This level focuses on the systematic structure and definition of KM processes. Sharing of knowledge is practiced. KM activities are part of daily workflow. KM systems, KM tools and mechanisms enable activities with respect to knowledge sharing. Initial understanding of KM metrics.

e) *Level 4*. Paulzen *et al*., [17] believe that the term quantitatively managed expresses the requirements of level 4 of CMMI v1.3. To enhance the systematic process management, measures of performance are used to plan and track processes. Use of metrics to measure and evaluate success. KM is self-sustaining. Training and instruction on KMS usage is provided. KM models and standards such as integrating knowledge flows with workflows are also adopted [26].

f) *Level 5*. The focus of this level lies on establishing structures for continuous improvement and self-optimization. Mechanisms and tools to leverage knowledge assets are widely accepted. KM tools are periodically upgraded/improved. Culture of sharing is institutionalized. Metrics are combined with other instruments for strategic control.

Pee *et al*., [6] suggested that the underlying structure of ideal KMMM should allow cross-references to proven management concepts or models [25] to support continuous learning and improvement [17]. Indeed, KMMM should adopt a multifaceted and socio-technical view of organizations, considering people, processes and technology.

4.2 Synergy between the Knowledge Areas

As shown in Figure 1, three dimensions of CMMI focus in people, procedures and technology. Process-focused maturity implies that process improvement should be centered on roles and work practices to define more effective procedures and methods. On another note, KM maturity is the extent to which KM is explicitly defined, managed, controlled and improved [6].

In assessing KM maturity of an organization, ascertaining how well each level of KM implementation is managed becomes important. KMMM must be judged from multiple perspectives including their knowledge areas: process, people/roles and technologies, to achieve an assessment of KM development [6, 7]. Each knowledge area is described by a set of characteristics [26]. At this point it is useful to emphasize that many of the common characteristics of CMM-based KMMMs are presented in Table 4.

Table 4. Knowledge Areas for CMM-based KMMMs

CMM-based KMMM	Knowledge Areas		
KMMM Siemens	Roles, Organization	Process	Technology and Infrastructure
KMMM Intel	Lessons Learned, Expertise, Data, Structured Knowledge		
KMCA	Lessons Learned, Expertise, Data, Knowledge documents		
KPQM	People	Organization	Technology
G-KMMM	People/ Organization	Process	Technology

KMMM Intel and KMCA models categorize knowledge assets into four knowledge areas: Lessons Learned (LL), Expertise, Data and Structured Knowledge or Knowledge documents. The authors [27] explain this categorization resulted from the realization that knowledge in each area has a unique: 1) mix of tacit and explicit content, 2) method of transfer and contextual value, and 3) life cycle including its shelf life.

Besides, LL process typically execute processes and define how to use episodic and tacit knowledge in an organization's activities, capturing the expertise from people whose knowledge might be lost if they leave the organization, shift projects, retire [12] or otherwise becomes unable to keep providing his knowledge. In contrast to LL and expertise, data and the knowledge contained in Knowledge documents are more permanent and represent explicit knowledge. Data can be a constant source of useful knowledge when used for analytical processing, detecting patterns, etc., whereas knowledge documents are product models, process definitions, method and technique evaluations, among others. We could associate LL and Expertise with people and process; Data and Structured Knowledge (or Knowledge documents) with process and technology (KM systems) that offer support for sharing knowledge, storage/retrieval categorizing and searching Knowledge Documents and Data. Therefore, each level of an organization's maturity level can be characterized in terms of the components: people/roles, process and technology. This is true for all CMM-based KMMM shown in Table 4.

Figure 3 presents interaction between the components to evaluate the current state of KM in practice within an organization and thus enabling continuous improvement. Enormous benefits have the potential to occur when balance between the above components is achieved [29]. Unfortunately, many practitioners tend to concentrate on isolated aspects that are mostly either human (people) or technology-centered and therefore miss the opportunities of an integrated KM approach [17].

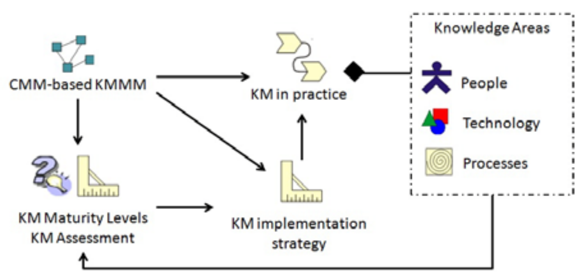

Figure 3. Interaction between components

If we consider the three Knowledge areas in Figure 3, we see that each one has its respective entities associated with software process entities defined by the Mexican standard. This is shown in Table 5.

Table 5. Knowledge Areas partnership with entities of Mexican standard

Knowledge Areas	Entities of NMX-I-059-NYCE-2005
People	Role
Technology	Resources (Infrastructure, Knowledge Base)
Processes	Processes (Base Practice)

The main contribution of part 03 of NMX-I-059-NYCE-2005 is its systematic approach, as it establishes relationships among roles, 9 processes and 70 work products in three categories (top management group, middle management group and operation group). The members of those groups recognize their responsibilities through assigned roles and develop software projects using assigned resources [12]. Each process has defined base practices, associating them to the process goals, work products, infrastructure, as well as the roles involved in the process and their general required training.

In addition, the Mexican standard suggests storing organizational knowledge, e.g., products, LL and work experience in a knowledge base; facilitating SMEs to learn form their accumulated knowledge.

4.3 SPI with CMM-based KMMMs

Davenport states that the most promising way to integrate KM into organizational processes is to embed KM into the technology people use to do their activities. Even in organizations that do not have explicit KM strategies or initiatives, people frequently tend to apply certain KM activities implicitly, and the technologies (resources) they use in their daily work may serve to partially support such activities [16].

We are considering that if we base KM implementation strategies upon the work done by the roles, considering explicitly the most relevant features from CMM-based KMMMs and a process reference model, according to their KM maturity levels and a process assessment model, then we will have KM best practices in a specific domain, which we could apply in a KM-based SPI project (Figure 4).

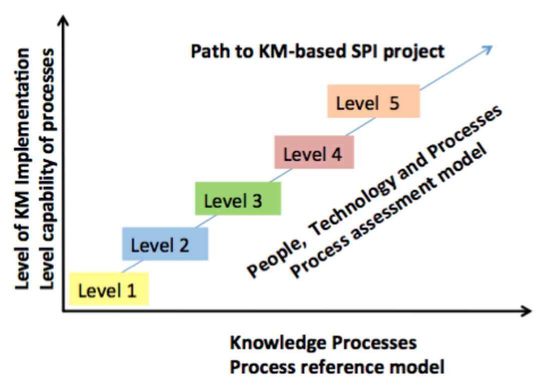

Figure 4. Representation of elements of a SPI model with elements of CMM-based KMMMs

5. Conclusions

Recently, organizations such as software development enterprises, want to get all the advantages of different process models that stimulate their harmonization and investigation of process improvement in multi-dimensional environments. While literature have provided evidence that large organizations or small and medium entities in software development are progressing along the pathway of CMMI improved performance, there is a lack of studies verifying such effects for CMM-based KMMMs for driving KM-based SPI projects. Studies examining the KM maturity level, along CMM-based KMMMs, in software development and maintenance processes improvement are needed.

In the CMM-based KMMMs reviewed, we observed that CMM's 5 maturity levels translate into 5 qualitatively different levels of KM maturity. Maturity levels of CMM-based KMMM may be assisted by the necessary technology support and integration of KM processes. In addition, people (roles) are who determine the extent to which organizational, tacit or explicit knowledge may be shared and includes aspects related to organizational culture, strategies, and policies. Understanding KM maturity from these different perspectives is expected to provide a comprehensive overview [22]. Investigation of the practices in each knowledge area at different KM maturity levels will be a natural direction for future research.

This paper presents some KMMMs that can be adopted in process assessment by Mexican standard NMX-I-059-NYCE-2005. The Mexican standard has a process reference model that is based on MoProSoft and it is complemented by the current Mexican standard NMX-I-006-NYCE (this conforms with the ISO/IEC 15504 standard). CMM and ISO/IEC 15504 indicate a quest to provide best practice collections that represents an accumulated knowledge base for a specific area [9, 31]. Considering the shortcomings of recent work, we could compare the two domains of CMM-based KMMM and process areas of ISO/IEC 15504.

One other note, in section 3.2, we present how the high abstraction level of knowledge management assessment methods does not provide information that is sufficiently detailed for diagnosis KM processes. In addition, KM reference models for KMMM is still an open research issue.

Acknowledgements

This work is being financially supported by UABC and PROMEP (grant: 103.5/11/840). First author would like to thank IDIS Group of Universidad del Cauca the infrastructure provided for this work.

References

[1] Klimko, G., "Knowledge Management and Maturity Models: Building Common Understanding", *Proceedings of the 2nd European Conference on Knowledge Management*, 2001.

[2] Arent, J. and Nørbjerg, J., "Software Process Improvement as Organizational Knowledge Creation: A Multiple Case Analysis", *Proceedings of the 33rd Hawaii International Conference on Systems Sciences*, 2000.

[3] Alavi, M. and Leidner, D. E., "Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues". *MIS Quarterly*, Vol. 25 No. 1, 2001, pp. 107-136.

[4] Von krogh, G., "Care in Knowledge Creation", California Management Review, Vol. 40, No. 3, 1998, pp. 133-153.

[5] Wong, K. Y. (2005). "Critical success factors for implementing knowledge management in small andmedium enterprises". *Industrial Management & Data Systems*, Vol. 105, No. 3, pp. 261-279.

[6] Pee, L. G., Teah, H. Y. and Kankanhalli, A., "Development of a General Knowledge Management Maturity Model", *Symposium of the Knowledge Management Society of Korea* (KMSK), Korea, 2006.

[7] Kuriakose, K. K., Raj, B., Murty, S. and Swaminathan, "Knowledge Management Maturity Models-A Morphological Analysis", *Journal of Knowledge Management Practices*, Vol. 11, No. 3, 2010.

[8] Teah, H. Y., Pee, L. G. and Krankanhalli, A., "Development and Application of a General Knowledge Management Maturity Model", *Pacific Asia Conference on Information Systems (PACIS)*, Malaysia, 2006.

[9] Pino, F. J., García, F., Serrano, M. and Piattini M. "Medidas para Estimar el Rendimiento y Capacidad de los Procesos Software de Conformidad con el Estándar ISO/IEC 15504-5:2006", *Revista Española de Innovación, Calidad e Ingeniería del Software, Vol. 2, No. 3, 2006*.

[10] *Capability Maturity Model^SM for Software (CMM)*, Version 1.1, Software Engineering Institute, Carnegie Mellon University, USA, 1993.

[11] Laporte, C. Y., Renault, A. and Alexandre, S, The Application of International Software Engineering Standards in Very Small Enterprises, Chapter II, In: *Software Process Improvement for Small and Medium Enterprises*: techniques and case studies, IGI Global, USA, 2008. Pp. 42-70.

[12] Flores Rios, B. L. and Rodríguez Elias, O. M., “Experience Factory Infrastructure as a basis for Knowledge Management in Software Process Improvement Program”, *Ibero-American Symposium on Software Engineering and Knowledge Engineering (JIISIC)*, Alfaomega, México, pp. 174-183.

[13] Flores-Rios, B. L., Gastelum Ramírez, S. L. and Rodríguez-Elías, O., “Modeling Knowledge Flow in Software Projects Management Process”, *International Conference on Knowledge Management and Information Sharing*, Spain, 2010, pp. 213-217.

[14] Webster, J., and Watson, R.T. 2002. "Analyzing the Past and Prepare for the Future: Writing a Literature Review," *MIS Quarterly*, Vol. 26 No. 2, June 2002, pp. xiii-xxiii.

[15] *CMMI® for Development, Version 1.3*, Software Engineering Institute, ESC-TR-2010-033, Carnegie Mellon University, 2010. USA.

[16] Rodriguez-Elias, O. M., Vizcaíno, A. Martínez García, A. I., Favela, J. and Piattini, M., Studying Knowledge Flows in Software Processes, *Software Engineering and Development*, Nova Publishers, 2009, pp. 37-68.

[17] Paulzen, O., and Perc, P., A Maturity Model for Quality Improvement in Knowledge Management, *Proceedings of the 13th Australasian Conference on Information Systems (ACIS 2002)*, 2002, pp. 243-253.

[18] Kulkarni, U., and St. Louis, R. Organizational Self Assessment of Knowledge Management Maturity, *Proceedings of the 9th Americas Conference on Information Systems*. 2003. pp. 2542-2551.

[19] Lee, J. and Kim, Y. “A stage model of organizational Knowledge Management: a latent content analysis”. *Expert Systems with Applications*, Vol. 20 Num. 4, 2001, pp. 299-311.

[20] Hain, S. and Back, A., *State-of-the-art on Maturity Models for Collaboration*, Universität St. Gallen, Switzerland, 2009.

[21] Langen, M. 2000. Knowledge Management Maturity Model – Holistic Development of KM with the KM maturity model, APQC Conference,

[22] Mettler, T., *Towards a Classification of Maturity Models in Information Systems*. University of St. Gallen, 2009.

[23] Alves, A. M., and Pessôa, M.S.P., Gestão do Conhecimento e Melhoria de Processo de Software - Pesquisa-Ação, *Conferência Iadis IberoAmericana WWW/INTERNET*, Lisboa, Portugal, 2008, pp. 43-50.

[24] Ehms, K. and Langen, M. *Holistic development of Knowledge Management with KMMM*, Seimens AG / Corporate Technology, 2002.

[25] Kochikar, V. P. *The Knowledge Management Maturity Model: A Staged Framework for Leveraging Knowledge*. Infosys Technologies Limited. KM World 2000, Santa Clara, Ca. USA.

[26] Pee, L.G. and Kankanhalli, A., “A Model of Organizational Knowledge Management Maturity Based on People, Process and Technology”, *Journal of Information & Knowledge Management,* Vol. 8, No. 2, 2009, pp 79-99.

[27] Kulkarni, U., and Freeze, R., Development and Validation of a Knowledge Management Capability Assessment Model, *Proceedings of the 25th International Conference on Information System,* 2004, pp. 657-670.

[28] Hsieh, P. J., Lin, B. and Lin, C. “The Construction and Application of Knowledge Navigator Model KNM: ” 2009.

[29] Minonne, C. and Turner, G., “Evaluating Knowledge Management Performance”, *Electronic Journal of Knowledge Management*, Vol. 7 Issue 5, 2009, pp. 583-592.

[30] De Gooijer, J. “Designing a knowledge management performance framework”, *Journal of Knowledge Management*, Vol. 4, 2000, pp. 303-310.

[31] *ISO/IEC 15504-5:2006, Information Technology – Process Assessment, Part 5*, An Exemplar Process Assessment Model.