Knowledge Capitalization in the Communities of Practice of Engineering

Akila Sarirete*, Azeddine Chikh**

**Institut National de Formation en Informatique*

Oued Smar, Alger, Algérie

asariret@hotmail.com

***Université de Tlemcen*

22, Rue Abi Ayad Abdelkrim, Fg Pasteur B.P 119 13000 Tlemcen Algérie

az_chikh@univ-tlemcen.dz

Abstract. *A successful accomplishment of engineering objectives requires a combination of technical specialties and expertise. Engineering becomes a team activity where various individuals involved are aware of the important relationships between specialties and between economic, political, and societal factors. With the vast movement towards promoting and developing models, practices, and technological environments in the domain of engineering, there is a need to facilitate communication, collaboration, and coordination amongst their actors. The purpose of this research paper is to solve the problem of capitalization of knowledge, tacit and explicit, in the domain engineering within the framework of an online community of practice (CoP). A generic knowledge model has been proposed to represent the CoP knowledge in the community memory, and the process of capitalization and management phases have been established. This work will contribute in proposing technology support for the CoPs and management of explicit and tacit knowledge.*

Keywords: *Knowledge management; Ontologies; Communities of Practice; Engineering;*

1. Introduction

Engineering activities of analysis and design for technical systems are not ends in themselves but are a means for satisfying human needs. In the systems era, successful accomplishment of engineering objectives requires a combination of technical specialties and expertise. Therefore, engineering becomes a team activity where various individuals involved must be aware of the important relationships between specialties and between economic, political, and societal factors. As stated by Blanchard B.S. *et al.*, (1998) engineering faces several challenges such as: i) Reduction in life-cycle cost should occur: this cost includes the cost of system design and development; production; operation and support; and retirement ii) Reduction in system acquisition: the time from the initial identification of a costumer need to the delivery of a system to the costumer iii) More visibility and a reduction in the risks associated with the decision making process. Hence there is a need to facilitate communication, collaboration, and coordination amongst the actors of engineering. A lot of research has been done to promote and develop good engineering models, practices, and technological environments (CAD: Computer-Aided Design, CAE: Computer-Aided Engineering). However, fewer efforts were deployed to support practitioners of the engineering domain in performing their job on a day to day basis.

The use of new information and communication technologies (ICT) has changed human interactions, their socio-economic structure, and, significantly, their way of learning. Today we live in a knowledge information society where citizens require fast services, better qualities, and improvement in efficiency and cost effectiveness. Companies, schools, universities, and organizations of all sizes are now turning towards ICT as an efficient and flexible tool of training, learning and professional development. It is a significant development in content as well as in services through virtual learning systems.

The present research paper focuses on knowledge capitalization issue in terms of knowledge and know-how tacit and explicit, within the framework of an online community of practice (CoP) of engineering. A generic knowledge model is being proposed to represent the CoP knowledge in the CoP memory along with the process of capitalization and knowledge management phases. CoP knowledge in the domain of engineering must include not only the basic knowledge of individual specialty fields of engineering but knowledge of the best practices captured from the previous developments of systems and products.

After this introduction section 2 will recall the knowledge management field and its relationship with the communities of practice. Section 3 will introduce the problem statement of this paper. Section 4 will explore the process of knowledge capitalization and show how it is integrated within the CoP. A generic learning scenario is proposed in section 5 to show how and where the knowledge should be capitalized and managed along with the process of capitalization and knowledge management phases. In section 6, a generic knowledge ontology is presented for the knowledge reification in the CoP memory and section 7 presents a case study of two online CoPs.

2. Knowledge management and communities of practice

Historically, there have been a number of tools facilitating knowledge management (KM) practices, but they were not designed to explicitly integrate communication, information sharing, and coordination. Until recently, most of the knowledge management (KM) efforts were based on a typical top-down approach where knowledge was seen as a separate entity and the focus was associated with the creation of central knowledge repositories, encouraging knowledge reuse and collaboration based on these repositories. Recent research on knowledge management (KM), however, clearly recognizes the importance of communities of practice in the creation and maintenance of knowledge within organizations (Kimble *et al.* 2004; Pan *et al.* 2003, Davenport *et al.*, 2002; Palette, 2006) to name but a few. Indeed, since the nineties Communities of Practice (CoPs) have attracted an increased number of academics and professionals from both the private and public sectors (Wenger *et al.*, 2002, 2004).

Today, CoPs are gaining more momentum and becoming a strategic approach for fostering learning and transferring knowledge through exchange, interaction, and negotiation with learning situated in practice. This differs from traditional perspectives on knowledge management where the focus is often on capturing, codifying, storing, and transferring knowledge with the stored knowledge often not reflecting real practices. The difficulty of capturing, codifying, storing and transferring the knowledge by KM systems shifted the focus towards more human aspects of knowledge such as Communities of Practice (CoPs) where human experience and the ability to make complex judgments based on past experience is widely present. The response in fulfilling engineering CoPs requirement is dependent on the scientists and engineers available in the needed fields of expertise and whether they are up to date and creative in their respective specialty areas. In some fields, such as e-learning (from the standpoint of engineering innovations), technological growth is fast. Engineers in these fields have to maintain constantly their skills.

The basic assumption underlying the theory of CoPs is that engagement in social practice is the fundamental process by which we learn and become who we are (Wenger, 1998). CoPs fulfill a number of functions with respect to the creation, accumulation, and diffusion of knowledge in an organization. CoPs have several characteristics that distinguish them from formal organizations and learning situations; such communities are groups of people who share a concern, a set of problems, or a passion about a topic, expand their practical knowledge and expertise in the area under consideration, and interact on an ongoing basis. In an environment of collaborative learning and knowledge sharing, community members learn from each other by making their knowledge and practices explicit, sharing them with their peers, and consequently reflecting on them. Communities of practice play an important role in the management of the tacit knowledge that the community members own (Kimble *et al.*, 2004; Wenger, 2004). The main objective is to establish a structure where tacit and explicit knowledge are shared and exchanged among various members within a given domain. The interacting processes of participation and reification are considered as fundamental. Participation forms the key element in the process of negotiation of meaning. It is the process through which people become active participants in the practice of a community. Reification means giving concrete form to something that is abstract.

Two of the fundamental components of a CoP are its "Community Learning Environment" and the "Community Memory" (figure 1). The CoP learning environment is composed of services and resources needed by community members. The CoP memory contains the reified or capitalized knowledge of the community.

Figure 1. **"***Community of Practice" structure*

3. Problem statement

The interest in engineering presents rich, yet still not fully exploited, opportunities to deliver high quality of related systems or products. The engineering process involves the use of appropriate technologies and management principles in a synergetic manner. Its application requires synthesis and a focus on process, along with a new "thought process" that should lead to a change in "culture" (Blanchard *et al.*, 1998). A lot of research has been done to promote and develop good models, practices, and technological environments as in the domain of learning design in e-learning (Cemal, 2003; Yu *et al.*, 2005). However, fewer efforts were deployed to support practitioners in performing their job on a day to day basis. There is a need to facilitate communication, collaboration, and coordination amongst actors of engineering. A strategic approach is to solve the problem of capitalization of knowledge, tacit and explicit, in this domain within the framework of an online community of practice (CoP). To meet these requirements we propose to have an organizational memory for resources, information, and knowledge need to be made available to the community members along with an ontology representing a uniform vocabulary for the CoP. The main research problem is: how to solve the problem of management and capitalization of knowledge, tacit and explicit, in this domain within the framework of CoPs?

In the following, we will explore the process of knowledge capitalization and show how it is integrated within the CoP. A generic learning scenario is proposed to show how and where the knowledge should be capitalized and managed along with the process of capitalization and knowledge management phases.

4. Process of knowledge capitalization within CoPs

One of the important parts in knowledge management is the capitalization of knowledge. According to Grundstein and Rosenthal-Sabroux (2008), knowledge should be considered as the organization's *capital*. This capital has to be increased and well managed. Capitalization is the process by which members of the community can identify, locate, model, store, access, use/reuse, share, update, and know-how to communicate the knowledge of the community.

Most researchers divide knowledge into two distinct forms: tacit and explicit. According to Polanyi "…all knowledge is either tacit or rooted in tacit knowledge. It is the kind of knowledge that cannot be articulated because it has become internalized in the unconscious mind" (Smith, 2003). We are all aware that "we know more than we can tell." (Wenger *et al.*, 2002). Not everything that we know can be explicit and expressed into objects, documents or tools. Recently Nonaka (1991) adapted the tacit definition of knowledge of Polanyi and defined the explicit and tacit forms of knowledge (Hildreth & Kimble, 2002). Explicit knowledge is the knowledge that is easily expressed, captured, stored and reused. It can be transmitted as data and is found in databases, books, manuals and messages. In contrast, according to Nonaka (1991), tacit knowledge is: "...highly personal. It is hard to formalize and therefore difficult to communicate to others ...tacit knowledge is deeply rooted in action and in an individual's commitment to a specific context ...tacit knowledge consists partly of technical skills [and partly] of mental models, beliefs and perspectives so ingrained that we take them for granted and cannot easily articulate them." (Nonaka, 1991; from Hildreth and Kimble, 2002).

Nonaka (1994) proposes the *SECI* model as a key to knowledge creation. This model consists of three main elements: four modes of knowledge conversion between the explicit and tacit knowledge, a shared context called "Ba", and knowledge assets. The interaction of the tacit and explicit knowledge is done through the four modes: socialization, externalization, combination, and internalization as follows:

- *Socialization*: sharing experience to create new tacit knowledge;
- *Externalization*: articulating and converting tacit to explicit knowledge. Tacit knowledge becomes explicit knowledge through metaphors, analogies, concepts, hypothesis, and models;
- *Combination*: restructuring and aggregating explicit knowledge into new explicit knowledge;
- *Internalization*: reflecting on explicit knowledge and internalize it into tacit knowledge.

The "Ba" can be defined as the *shared context* where the four modes of knowledge conversion happen (Nonaka *et al.*, 2000). Naeve *et al.* (2005) call the Ba as "a place for interactive knowledge creation". It is divided to four contexts respectively to each knowledge mode: Originating Ba, Dialoguing Ba, Systemizing Ba, and Exercising Ba. The SECI model is mainly applied in organizational setting and knowledge management. Naeve *et al.* (2005) proposes to extend this model to learning management setting. In the CoP context, learning is important and knowledge should be shared and externalized whenever possible. Here, the CoP is considered as the context of learning and sharing. Figure 2 shows the SECI framework applied to the context of a CoP.

Figure 2. *SECI Model adapted from Naeve et al. (2005) to the CoP Context*

Figure 2 shows that the individual knowledge of the community members can be shared through the SECI cycle of knowledge creation. Individual and collective knowledge and learning are then increased. We emphasize here that at each step of the SECI framework, knowledge needs to be capitalized. The process of knowledge capitalization can be seen as a cycle with several steps, as shown in figure 3. We adapted the knowledge capitalization process from an organizational setting as stated by Grundstein and Rosenthal-Sabroux (2008) to the CoP context. It consists in locating the crucial CoP knowledge (knowledge identification, mapping, and classification) (Originating and Dialoguing Ba), actualizing it, enhancing it (Dialoguing Ba), and preserving it (modeling, formalizing, and archiving) (Systemizing Ba) by bringing several perspectives of the community members within different contexts.

Figure 3. *Knowledge Capitalization within CoPs adapted from Grundstein et al. (2008)*

Knowledge creation scenario in the CoP

Figure 4 shows a generic scenario with knowledge management phases within a CoP. The Knowledge Holder is the expert member and can either transfer tacit knowledge to a Knowledge Seeker (participant member) through socialization or create explicit knowledge and uses Services, and Resources to store it in the Community Memory through externalization process. In this process the role of the Knowledge Coordinator is to facilitate the tacit knowledge transfer. The Knowledge Organizer is a support member or a CoP service that models the knowledge, combines it with existing knowledge and archives it in the Community Memory. Besides his knowledge, the Knowledge Seeker uses the explicit knowledge and learns through practice. This process leads to internalization. The performance of the Knowledge Seeker is returned to the Community Memory as feedback.

Figure 4. *Knowledge Management Phases within a CoP.*

A macro level view of the SECI model within the CoP context is to consider it as process within the overall knowledge creation. This process has to be triggered by some input and leads at each step of the SECI to an assessment of the newly created knowledge among the actors of the CoP (figure 5). This knowledge has to be assessed by the community members. In case of agreement, it will be fed into the CoP memory, if not, another cycle of the SECI process is triggered.

Figure 5. *SECI Process within a CoP.*

5. Generic learning scenario in a CoP

In our work on modeling learning scenarios in a CoP (Chikh *et al.*, 2008), we proposed three main learning situations that can happen in a CoP: a problem-based situation, a decision-based situation, and a project management situation. These situations can occur in an online learning system engineering process through the CoP activities. In this paper, we propose to generalize these learning situations to a more generic scenario where the members can be in any learning situation. The main trigger of this situation is that a member could be confronted with a problem, an idea, an objective to achieve, or an event that occurred in the CoP and need to be addressed. The output of this scenario is some knowledge that can be identified as lessons learned and outcomes that need to be shared and capitalized in the CoP environment (Figure 6).

Figure 6. *Learning Process within a CoP*

The CoP members can use the CoP environment to make their choices and decisions and share their best practices which should be saved after agreement in the CoP memory for a possible reuse. During these phases, the CoP follows the knowledge creation steps as shown in figures 2 and 3 to build its knowledge.

6. Generic ontology for representing CoP knowledge

The CoP members need a shared vocabulary to be able to represent the concepts, the knowledge and the communication within the CoP. This shared vocabulary can be represented by means of ontologies. An ontology as stated by Gruber (1995) "…is an explicit specification of a conceptualization". More specifically, "an ontology is considered as a description of the concepts and relationships that can exist for an agent or a community of agents" (Abel *et al*., 2004).

In previous work we defined a generic ontology to represent the CoPE (Community of Practice of E-learning) environment and its members (Chikh, *et al.,* 2008; Sarirete *et al.* 2008). Beside this ontology we are now adding a knowledge ontology which is used to define a high level ontology of the knowledge used in the CoP. To take advantage of the assets in the CoP, we propose to categorize the knowledge, based on the four modes of the *SECI* framework (figure 7) as defined by Nonaka *et al.* (2000): *experiential, conceptual, systemic*, and *routine* knowledge assets.

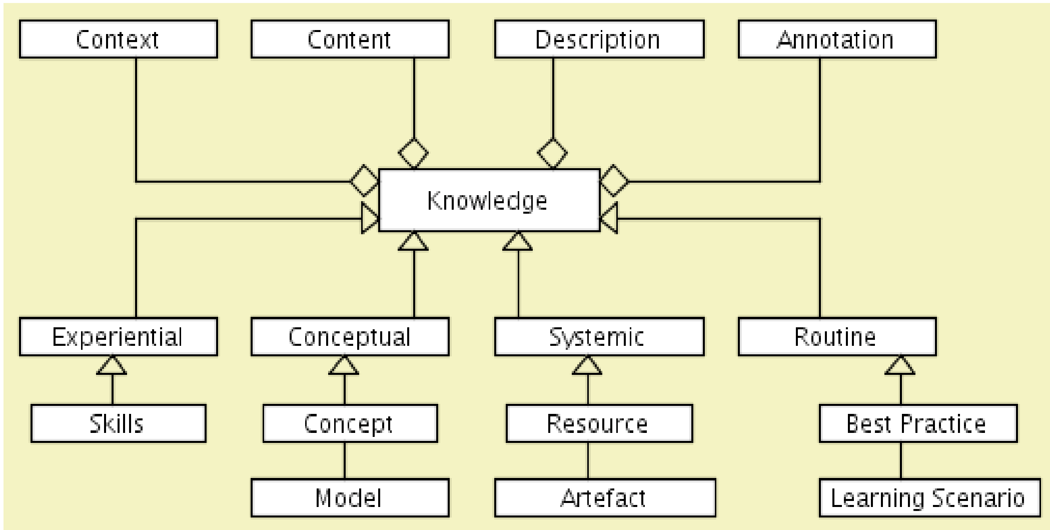

Figure 7. *Knowledge Conceptual Ontology in a CoP*

- Experiential knowledge assets can be seen as hands-on experiences; skills acquired through dialogue, discussion and shared practice.
- Conceptual knowledge assets consist of explicit knowledge articulated through images, symbols and language. These assets are based on the concepts held by members and stakeholders of the community.
- Systemic knowledge assets consist of systematized and packaged explicit knowledge, such as explicitly stated technologies, product specifications, manuals, and documents.
- Routine knowledge assets consist of the tacit knowledge that is customized and embedded in the actions and practices of the organization.

The concept "Knowledge" as described in figure 7 is composed of several other concepts:

- Description: describes briefly the knowledge in question.
- Context: describes where the knowledge is used and may show different views of the knowledge uses.
- Content: shows some of the knowledge contents: what is it about?
- Annotation: is a text form that is used to help identify appropriate knowledge and the reasons for creating such knowledge.

Figure 8 shows part of the knowledge ontology represented in OWL[1] language.

[1] http://www.w3.org/2004/OWL

```
<owl:Class rdf:ID="Best_Practice">
  <rdfs:subClassOf rdf:resource="#Routine"/>
  <rdfs:label rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >Best Practice</rdfs:label>
</owl:Class>
<owl:FunctionalProperty rdf:ID="Context">
  <rdfs:domain rdf:resource="#Knowledge"/>
  <rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#string"/>
  <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#DatatypeProperty"/>
</owl:FunctionalProperty>
<owl:FunctionalProperty rdf:ID="Annotation">
  <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#DatatypeProperty"/>
  <rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#string"/>
  <rdfs:domain rdf:resource="#Knowledge"/>
</owl:FunctionalProperty>
<owl:FunctionalProperty rdf:ID="Content">
  <rdfs:domain rdf:resource="#Knowledge"/>
  <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#DatatypeProperty"/>
  <rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#string"/>
</owl:FunctionalProperty>
<owl:FunctionalProperty rdf:ID="Description">
  <rdf:type rdf:resource="http://www.w3.org/2002/07/owl#DatatypeProperty"/>
  <rdfs:domain rdf:resource="#Knowledge"/>
  <rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#string"/>
</owl:FunctionalProperty>
```

Figure 8. *Extract of the Knowledge ontology represented in OWL language*

7. Case study: Application of SECI model to "CPsquare" and "The Cisco Learning Network" CoPs

The methodology adopted in this study is based on action research. Action research is an established research that simultaneously assists in practical problem solving and expands scientific knowledge (Baskerville, 1999). Action research is performed collaboratively and enhances the competencies of the respective actors in the project. In this action research we participate and act in the community of practice, and simultaneously evaluate the results of this participation. This is a twofold objective: in one hand we aim to understand/participate in the design of a community of practice, and on the other hand we aim to contribute to scientific knowledge by creating common framework for practitioners in the engineering field. The methodology adopted was applied to two communities of practice: "CPsquare" CoP and "The Cisco Learning Network" CoP.

Qualitative analysis and discussion

In this qualitative analysis, we are exploring two communities of practice: "CPsquare" CoP and "The Cisco Learning Network" CoP. CPsquare uses as a core platform Web Crossing[2], a community based discussion tool. The Cisco Learning Network used jive software[3]. Table 1 lists the main mission of the two communities and their knowledge bases.

[2] http://www.webcrossing.com/Home/
[3] http://www.jivesoftware.com/

Community	"The Cisco Learning Network" Community (https://cisco.hosted.jivesoftware.com/community/learning_center)	CPsquare (http://www.cpsquare.org) Community of Practice on CoPs
Mission/Objective	Sharing knowledge about computer networking field (certifications, teaching, providing engineering solutions, etc.)	Learning by sharing and supporting each others' professional practices in a process of dialogue, trust-building and mutual support (Stuckey and Smith, 2004).
Community Memory	Knowledge Base divided into three components: • Technology Library: technical resources • Business Library: papers on business soft skills • Other documents: contributions from members • Cisco Support Wiki: contributions from members to solve support issues	Knowledge Base called "Cybrary": organized in a hierarchy of folders that the community leader organizes. The members may create new folders also. A meaningful name should be given to the folder for better retrieval.
Knowledge objects	• Collaborative document: in general a wiki based document giving the steps for solving a certain issue • Documents (Word, RTF) • Spreadsheets • PowerPoint presentations • Acrobat PDF • Images • Videos • Compressed files • Discussion forums • Blogs	• Discussion forums • Project based wikis • Documents (Word, RTF): white papers, research papers; discussions summary documents • PowerPoint presentations • Acrobat PDF • Images • Videos • Blogs • Links to other external resources (e.g. wikispaces.com)

Table 1. *"CPsquare" and "The Cisco Learning Network" CoPs*

In table 2 we show the knowledge capitalization process related to the SECI framework for the two communities.

SECI modes	"The Cisco Learning Network" CoP	"CPsquare" community
Socialization Clarification – Dialogue	Members initiate dialogue through a discussion forum mainly about specific questions or some other inquiries related to the networking field	Community leader of members initiate dialogue through discussion forums, phone bridge and/or email mainly about a project, a research work
Externatilization Conceptualization – Dialogue	Discussion continues through the forum. Other members suggest solutions to the question or point to the existing documents in the support wiki	Member conceptualize their project into sub-tasks and most of the time create a wiki page to have a collaborative place to share the ideas and concepts
Combination Modeling – Connecting	Modeling is done through documents that are stored by members in the knowledge base. No specific criteria in the modeling process	Modeling is done mainly through wiki creation following a known structure among members or the creation of summary documents that are used as annotations for the video or podcast recording
Internalization Practice	Depends on individual members.	Members practice their skills in moderating other projects and sub-teams in the CoP
Knowledge organization	No specific criteria for the organization of the knowledge base. The only criteria is based on technology/business/support	Uses a taxonomy-based knowledge base based on folder structure and on community members agreement for the content.
Knowledge retrieval	Based on classical search engines	Based on members navigation skills through the community space and knowledge base.

Table 2. *SECI model applied to "CPsquare" and "The Cisco Learning Network" CoPs*

The two CoPs studied here share their documents in an easily accessible repository based on categories. Most of the capitalized knowledge in these CoPs comes under the form of systemic knowledge which consists into explicitly creating documents and artifacts. However, there is no clear distinction between the different knowledge asset types as we have stated in section 6. The capitalization of the experiences, skills, and shared practice scenarios is missing. There is also a shortage in conceptual formulation of knowledge into models or concept maps that can be reused by community member to solve similar scenarios or problems. The routine knowledge assets showing processes and actions of experts are not capitalized. By applying the adapted SECI model to CoPs it's clear that most of the capitalized knowledge in the community memory of communities of practice is explicit only. Tacit knowledge, however, is still in each individual member's memory, and consequently is not externalized as it should if the adapted SECI model was applied. We believe that using the adapted SECI model not only will ensure the capitalization of the explicit knowledge but the tacit knowledge as well.

8. Conclusion

A lot of research has been done to promote and develop good engineering models, practices, and technological environments. However, fewer efforts were deployed to support practitioners of this domain in performing their job on a day to day basis. In this paper we focused on solving the problem of capitalization of knowledge, tacit and explicit, in the domain of engineering within the framework of an online community of practice (CoP) by providing a framework for the knowledge capitalization within the CoP. This knowledge capitalization framework is based on Nonaka's SECI model. A generic knowledge model has been proposed to represent the CoP knowledge in the community memory. The aim is to contribute to the learning process of individuals and organizations. The application of the adapted SECI model to two communities of practice "CPsquare" and "The Cisco Learning Network" has shown that most of the capitalized knowledge in the community memory is explicit only while tacit knowledge is not externalized. Using the adapted SECI model not only will ensure the capitalization of the explicit knowledge but the tacit knowledge as well. We believe that communities of practice and social learning have a huge impact on learning as well on knowledge sharing. Presently we are focusing on completing the domain ontology of a CoP in the domain of e-learning and apply the proposed framework using this ontology.

References

Abel, M.-H., Benayache, A., Lenne, D., Moulin, C., Barry, C., & Chaput, B.: Ontology-based Organizational Memory for e-learning. Educational Technology & Society, 7 (4), 98-111. (2004)

Baskerville, R.L., Investigating Information Systems with Action Research, Communication of the Association of Information Systems, Volume 2, Article 19, October 1999. http://www.cis.gsu.edu/~rbaskerv/CAIS_2_19/CAIS_2_19.html

Blanchard B.S., Fabrycky W.J.: Systems Engineering and Analysis. 3rd edition Prentice-Hall, (1998).

Cemal, A.: Creating an Interactive and Collaborative e-Learning Environment in Educational Processes. Turkish Online Journal of Distance Education-TOJDE , Vol. 4, No. 3, July 2003

Chikh, A., Berkani, L., Sarirete, A.: Modeling the Communities of Practice of E-learning "CoPs". Proceedings of the Fourth Annual Conference of Learning International Networks Consortium (LINC). Jordan, October 27- 30, 2007

Chikh, A., Berkani, L., Sarirete, A.: IMS-CLD: a new Specification for Learning Scenarios in CoPs. Proceedings of The Fourth International Conference on Web Information Systems and Technologies. May 4-7 , 2008 Funchal-Madeira – Portugal (2008)

Davenport, E. and Hall, H.: Organizational knowledge and communities of practice. In B. Cronin (Ed.). Annual Review of Information Science and Technology (Vol. 36, pp. 171-227). Medford NJ: Information Today (2002)

Grundstein, M., Rosenthal-Sabroux, C.: GAMETH, A Process Modeling Approach to Identify and Locate Crucial Knowledge, In Proceedings the 12th World Multi-Conference on Systemics, Cybernetics and Informatics KGCM 2008, pages 49-54, 2008.

Hildreth, P., & Kimble, C.: "The Duality of Knowledge", Information Research, Vol. 8 No. 1, October 2002. Retrieved on December 22nd 2006.

Kimble, C. and Hildreth, P.:"Communities of practice: Going one step too far?" AIM, pages 1–7, 2004. URL http://www.cs.york.ac.uk/mis/docs/AIM14.pdf.

Leblanc, A., Abel, M.H.: E-MEMORAe2.0: an e-learning environment as learners communities support. International Journal of Computer Science & Applications. Vol. 5, No. 1, pp. 108-123. (2008)

Naeve, A., Yli-Luoma, P., Kravcik, M., Lytras, M., Simon, B., Lindegren, M., Nilsson, M., Palmér, M., Korfiatis, N., Wild, F., Wessblad, R., Kamtsiou, V., Pappa, D., Kieslinger, B. (2005). A Conceptual Modelling Approach to Studying the Learning Process. PROLEARN: European Commission Sixth Framework Project (IST 507310).(45 pages)

Nonaka, I.: A dynamic theory of organizational knowledge creation, Organization Science, Vol. 5, No. 1, pp. 14-37 (1994)

Nonaka, I., Takeuchi, H.: The knowledge-creating company: How Japanese companies create the dynamics of innovation, New York: Oxford University Press. (1995)

Nonaka, I., Toyama, R., Konno, N.: SECI, Ba and Leadership: a Unified Model Knowledge Creation, Long Range Planning, Vol 33 (2000), Elsevier Science Ltd.

Palette: Pedagogically sustained Adaptive LEarning Through the exploitation of Tacit and Explicit knowledge; url: http://palette.ercim.org/ (2006)

Pan, S. L. and Leidner, D. E.: Bridging communities of practice with information technology in pursuit of global knowledge sharing. Journal of Strategic Information Systems, 12:71–88, 2003.

Sarirete, A., Chikh, A., Berkani, L.: Onto'CoP: Ontology for Communities of Practice of E-learning. Proceeding of ECTEL 2008, Maastricht, Netherlands 16-19 September 2008. (2008)

Smith, M. K.: Michael Polanyi and tacit knowledge. The encyclopedia of informal education, www.infed.org/thinkers/polanyi.htm. Retrieved from http://www.infed.org/thinkers/polanyi.htm. May 31st 2007. (2003)

Stuckey, B., Smith, J.D.: Building Sustainable Communities of Practice, in Hildreth, P. & Kimble, C. (Eds.), Knowledge Networks: Innovation through Communities of Practice, Hershey, PA: Idea Group.150-164. (2004)

Yu D., Yang W., Chen X. 2005.: New Era of E-Learning. Proceedings of the First International Conference on Semantics, Knowledge, and Grid.

Wenger, E.: Communities of Practice: Learning, Meaning and Identity. Cambridge University Press, New York, USA, 1998.

Wenger, E., McDermott, R., and Snyder, W. M.: Cultivating Communities of Practice. Harvard Business School Press, Boston, USA, (2002)

Wenger, E.: Knowledge management as a doughnut: Shaping your knowledge strategy through communities of practice; Reprint # 9B04TA03; IVEY MANAGEMENT SERVICES January/February 2004;