Towards a Semantic Social Collaborative Environment for Organizational Learning

A. L. Menolli, A. Malucelli, and S. Reinehr

Abstract-- **Organizational learning is an area that helps companies to improve significantly their processes through the reuse of experiences. For knowledge intensive areas, such as software engineering, it is extremely important that the acquired knowledge be systematically stored and reused. However, to make learning possible in software development companies is not an easy task, since it is an area in which processes and knowledge are usually internalized in the mind of their employees. Therefore, it is necessary to create environments that promote and motivate information sharing and knowledge dissemination. In addition, it is important that all acquired knowledge be organized to be reused faster, easily and efficiently whenever necessary. This paper proposes a semantic social collaborative environment to facilitate and enhance organizational learning within software organizations. The environment integrates constructivist and instructionist learning theories; combines Web 2.0 technologies; and makes use of ontologies to represent organizational knowledge.**

Index Terms **-- Ontologies, Organizational Learning, Semantic Web, Software Engineering.**

I. INTRODUCTION

Knowledge is an essential property for companies in contemporary economics. More than ever before, knowledge has been spread out among individuals, teams and organizations. Thus, the capacity to create, acquire, integrate, implement and disseminate knowledge has emerged as a fundamental competence for organizations in general [1]-[2]. To be successful, companies must not only explore current knowledge but also invest continuously in the search for new knowledge as strategic options for future decisions and as a way to develop competitive edge [3].

Many works have tried to identify factors that could help, or even automate learning in the corporate environment, some of them in the software engineering area, because it is knowledge based processes area. Among the works found in the literature whose objective is to support learning in the software engineering area, some have tried to improve communication among software development teams, while others have contributed to knowledge management in software organizations and are related to e-learning environments using semantic resources.

Carreras et al. [4], proposes a Collaborative Work Environment to promote efficient and effective collaboration among professionals, specially distributed in different places in the company, or among stakeholders from different companies. Appelt [5] also propose an environment conducive of collaborative work.

Many of the works developed in this area are not focused on the development of collaborative environments, but have concentrated their efforts on knowledge management in software projects. The objective of these works is to systematize learning in projects, working mainly with the Experience Factory concept [6]. Holz et al. [7] propose a management approach centered on a process that promotes organizational learning. Althoff et al. [8] proposes architecture of an experience environment for software engineering.

Some works also make use of semantic resources and are focused on e-learning. Zouaq and Nkambou [9] introduce an approach that allows the accumulation of existing pedagogical resources, creating the first content metadata based on text mining and natural language processing, to develop learning objects dynamically. Capuano et al. [10] introduces an e-learning solution called Intelligent Web Teacher (IWT), which is capable of modeling knowledge about educational domain.

In some of these works [4]-[10], collaborative tools and environments which use resources such as wiki, blogs and social networks, are cited as substitutes for company intranets, creating an environment in which workers communication and collaboration take place more effectively, offering a collaborative environment in which organizational learning is possible.

However, there are several gaps which must be filled so that organizational learning can really take place in companies, such as providing only contents that are necessary for the organization in a contextualized way, allowing the mapping of organizational competences, as well as, its deficiencies and needs, and facilitating each individual's learning based on the knowledge acquired by the organization. Works with the objective to promote the exchange of information and promote communication among development team members have approached only one of the important aspects of organizational

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learning. Neither of these works is concerned with individual learning or whether the stored knowledge will be useful to users. As for the works on educational aspects, they lack the specific learning characteristics of organizational environments, which are different from other learning environments.

Therefore, this paper tries to fill these gaps by proposing a semantic collaborative organizational environment, combining semantic resources, organizational learning and learning concepts, to support organizational learning in software development organizations thus maximizing team members learning.

The remaining parts of the paper are organized as follows: Section II presents background information on semantics organizational learning and on the main concepts behind the proposed environment. Section III introduces the proposed environment as well as its architecture and the chosen knowledge representation. Section IV presents the final considerations of this study.

II. BACKGROUND

A. Semantic Learning Organization

In the last couple of years, organizations have started to value even more the experience and know-how of their employees, *i.e.*, their knowledge [11]. This knowledge is applied to companies in different ways such as in organizational routines, production practices and in relationships among employees. Thus, the challenge to develop and implement processes that generate, store, organize, disseminate and apply knowledge produced and used in the company in a systematic, explicit, reliable and accessible way to the organization community is risen.

Therefore, a concept that can help the management of organizational processes is organizational learning. Organizational learning, according to Senge [12] and Ali [13], can be defined as a continuous testing of experience and the transformation of this experience into accessible knowledge to the whole organization and, more importantly, relevant to its fundamental purposes.

However, for a company to apply organizational learning concepts it is necessary to use knowledge generated by its members systematically and reliably. To do that, this knowledge, which many times are the sole property of one individual only, must be disseminated. There are several tools to help information exchange and the communication among organization members, and, consequently, knowledge dissemination. Many of these tools adopt semantic technologies based on Semantic Web proposed by Berners-Lee [14]. According to Berners-Lee, the Semantic Web is not separated from the Web but an extension of it, in which a well-defined meaning is given to information, making computers and people work in cooperation.

The Semantic Web is a fast-growing area which has been the object of several research studies. Semantic Web techniques, concepts and applications are being used in several areas, creating new research lines such as the educational systems based on Semantic Web [10] and semantic learning organization.

Semantic Learning Organization (LSO) is a concept that extends the notion of learning organization in the technological dimension [15], *i.e.*, it is not only the application of semantic technological resources to organizational learning, but, mainly, the use of technologies that provide a representation of shared knowledge about an organization domain and a context to measure and intensify learning activities.

Therefore, semantic learning organization can be considered the application of Semantic Web resources to promote organizational learning within a company, and, according to Sicili and Lytras [15], Semantic Web technologies must be applied not only to improve learning processes but also as a tool to promote behavior changes.

There are tools and technologies that have been applied by organizations to improve learning and communication among their members, using the semantic organizational learning concept in some ways.

B. Environments and Tools applied to Organizations

For organizational learning to occur, it is necessary a change in culture, communication improvement and, most importantly, the adaptation of the company and its members to new realities.

Each company must evaluate the technologies available to choose the most adequate to promote and facilitate learning in the organization. Besides the traditional technologies already being used by companies such as intranet, online communication tools, shared data banks and other technologies that give support to knowledge communication and storing, there are new technologies which can be applied in the search for organizational learning. Among the new technologies, the Web 2.0 stands out since, according to Rech and Ras [16], Web 2.0 technologies promote distributed collaboration, motivating the free reuse of information, experiences, or products and give support to knowledge workers by dealing with the information overload, integrating and reusing information spread out by several sources of content. Among Web 2.0 technologies, the most used in organizational learning tools, according to Rech and Ras [16], are:

- Wikis: allow collaboration among people to share ideas, experiences and links;
- Web Blogs: content distribution platforms to share news on a specific theme and are used to share knowledge, experiences and documents;
- Discourse Systems: are the substitutes of notice board, and it is used systematically to discuss relevant themes with or without the help of moderators, and provide valuable experiences in a distributed environment, but highly participative;
- Folksonomies: are “bottom-up” created taxonomies based on tags (keywords) freely assigned by the users of a system.

Besides the Web 2.0 technologies, other technologies can help in the construction of a semantic platform for organizational learning, such as ontologies, which abstract knowledge of a certain domain and represent it formally

through conceptualization, expressed in formal logics [17].

C. Learning in Corporate Environments

The primary objective of the implementation of computational environments based on the technologies described in the previous section is not organizational learning, but rather to offer collaborative environments which can facilitate communication in companies. Besides being a requirement for learning to occur, collaboration is only one of the necessary components, thus it is not sufficient to make use of technologies such as Wiki. Therefore, other technologies, tools and methods should be used to create a semantic environment to intensify learning activities, helping to promote effective organizational learning.

One area that can complement potential Semantic Web technological impacts on organizational learning mechanisms is the Educational Semantic Web. This area focuses mainly on the final result of learning and neglects mostly the perspective of individual and collective learning [15]. Thus, according to Sicili and Lytras [15], organizational and educational viewpoints should not compete but complement each other, since the latter deals with important questions that include learning based on activities, pedagogical modeling and metadata profiles coherence, among others; therefore these two visions must be used together to enhance organizational learning.

This way, semantic educational environment concepts that are used for learning can be adapted and applied to organizational learning such as those found in e-learning environments.

E-learning is a distance teaching environment supported by technology, *i.e.*, environments based on educational web semantic assumptions. Organizational learning environments, therefore, should not be only communication tools but also environments that give support to learning, including many of e-learning properties.

In addition, organizational environments should not be an adaptation of e-learning systems. For this to occur, these environments must have characteristics different from those of learning, as shown in Table I.

Among the main differences between e-learning and organizational environments, the non-presence of a tutor stands out in the organizational environments. In an organizational environment, the absence of a tutor may compromise the adequacy of the material. Therefore, sequencing materials to guarantee learning of a specific content becomes a challenge.

Table I. Differences between Educational and Organizational Environments

Educational Environment	**Organizational Environment**
Users have similar knowledge levels	Users may have different knowledge levels
The presence of tutors	No tutors
Materials are inserted by tutors	Any person can insert materials
Users must follow the modules sequence	There is no pre-established sequence of contents
Normally concerned with one type of knowledge only	May be concerned with few types of knowledge at the same time
Context is not important	Context is very important
The presence of evaluation resources	Difficult to assess learning

Another difference between the two environments is content depth. Normally the focus of learning in an organizational environment is more specialized than in an e-learning environment.

Besides the problems related to the content posted by an environment and their recovery, as exposed above, other organizational issues must be dealt with in a semantic learning organization, such as:

- Competences Management: company needs as well as individual competences and objectives must be mapped.
- Entrepreneurship and innovation incentives: personalized information depends on workers' competences and interests.
- Organizational mission awareness: the formal representation of a mission allows the connection between company mission and activities specification.
- Learning development satisfaction survey: workers' feedback is important to reach to conclusions on business unit climate.
- Development and representation of shared knowledge: the sharing and evolution of artifacts must be allowed to reach shared conceptualization.

III. PROPOSED ENVIRONMENT

Software development is an intensive knowledge area for which storage and dissemination of knowledge, errors and questions are of extreme importance. However, this is not the only issue to be considered by software development companies. For an efficient learning to take place it is necessary for companies to identify their weaknesses, market trends and future needs, to be able to deal with them. To do so, it is important to know the organizational and individual competences, helping the organization to improve their capacities and even to develop new ones.

Therefore, as exposed before, this paper aims to present a proposal of a semantic collaborative organizational environment to promote organizational learning in software development companies. To meet this objective, this environment must have the necessary characteristics presented in Table II.

So, to achieve these characteristics, the proposed environment organizes the knowledge in learning objects and units of learning, integrating constructive learning theories, in which participants exchange information, helping them construct and improve their cognitive model [18], and instructionist theories, which maintain the control of interactions [19]. Polsani [20] states that a learning object is an independent and autonomous learning contents unit that can be reused in several teaching contexts, while unit of learning concept defines a general module of an educational process, like a course or a lesson [21].

Therefore, one of the main characteristics of the proposed environment is knowledge sharing, an essential characteristic for organizational learning to happen. To learning occurs, it is necessary socialization [22], which takes place through the sharing of experiences among people. One technology that can

facilitate socialization is social networks, so the proposed environment is based on social networks that can improve the sharing information and maximize socialization.

Table II. Learning Environment Characteristics

CHARACTERISTICS	DESCRIPTION
Knowledge flow to all employees	Generated knowledge may be accessed by all, and any person can generate knowledge within an environment.
Individual and collective learning through the exchange of experiences	People must learn through exchange of experiences. This learning is firstly individual, when one becomes aware and understands the subject. Then it becomes collective when it is codified in artifacts and documents.
Productive intellectual environment for discussions, ideas and knowledge construction	The environment must offer mechanisms for discussions and ideas exchanging leading to collective knowledge construction.
Individual and organizational competences management	Organization competences and roles must be mapped and managed to identify needs and help it meet its objectives.
Pedagogical organization of knowledge according to the cognitive profile of each user	Knowledge must be pedagogically organized for each type of user, respecting the cognitive profile of each user, facilitating learning.
Knowledge contextualization	Knowledge must be contextualized according to the business processes of the organization, helping comprehension and facilitating its assimilation and favoring its reuse.

Another technology that contributes to socialization and is integrated to the proposed environment is wiki, which promote both, the externalization and internalization of knowledge. According to Kimmerle et al. [23], wikis adopt the constructivist approach to knowledge acquisition and it can help the process of internalization and externalization of knowledge, using the constructivist approach [23].

In addition to the issues raised before, Ding et al. [24] suggest that reputation systems are integrated to social networks, mapping people to improve trust relations and disseminating them through social relations.

So, the proposed environment uses social networks to organize the company's projects and facilitates the communication among the members. Furthermore, it is proposed to use activities panel for concentrate all collaborative tools. The tools proposed to be part of the activities panel are: Wikis, Discussion Systems, Whiteboards and Folksonomia.

In the proposed environment users can insert external materials such as videos, tutorials and others to complement knowledge acquisition.

Being a semantic environment, it is proposed that all knowledge representation generated by collaborative tools and by the insertion of external materials should be organized in ontologies.

The ontologies integrated into the proposed environment are presented in the next section to make organizational learning possible. The architecture of the environment with a detailed description of each component is presented in Section B.

A. Semantic Knowledge Representation

This work proposes that the different collaborative tools are integrated and organized by a common representation which allows that different types of collaborative tools are integrated and organized for projects in the software development area. Thus, ontologies were defined to guide the organization of these collaborative tools, introducing a common vocabulary, helping knowledge acquisition in such a way that all knowledge is organized according to the specific needs of software development companies. So, this section introduces the Learning Design Ontology (LDO), the Didactic Domain Ontology (DDO), and the Competence Ontology, which are used to represent and organize the proposed environment.

A.1 Learning Design Ontology

In the proposed environment, all knowledge generated by the insertion of materials and contents, by the several members of the organization, is classified and organized according to their pedagogical function. Thus is proposed organize the knowledge in a Learning Designed Ontology (LDO).

So, it is proposed to adapt the Learning Design Ontology (LDO) developed by Amorin et. al [25], that was created from the IMS Learning Design (IMS LD) that is a Educational Modelling Language (EML). EML are models of semantic information and aggregation that describe, from a pedagogic point of view, the content as well as the educational activities [25]. These elements are organized into units of study with the aim of allowing their reuse and interoperability [26].

The Learning Design ontology selected was developed by creating a concept taxonomy, which describes the elements of the IMS LD conceptual model and the IMS LD information model, and a set of axioms [25]. However, due to the differences already mentioned between educational learning and organizational learning, it is proposed to adapt the IMS LD ontology for an organization learning design.

A.2 Competency Ontology

In any environment designed for organizational learning, competences management is a fundamental factor, since it is the way organizations manage organization, groups and individual competences. It is through competence that some knowledge, know-how and attitudes are put into practice within a specific context [27].

A company that wishes to improve the knowledge of its employees and groups must know their qualities and prioritize learning in areas which the company does not have satisfactory qualification. According to Berio and Harzallh [27], competence can be managed and classified in identification, estimation, acquisition and use. For an effective improvement in the critical sectors proposed by this work, the use of a competence ontology based on the work of Paquette [28], which will model the competences, combining knowledge concepts, skills, attitudes and performance, thus from this ontology the learning of the individuals can be driven according to their capabilities and necessities.

A.3 Didactic Domain Ontology

For creating knowledge from social tools, it is necessary that all content generated by the insertion of materials by the several members collaboratively is classified and organized according

to their pedagogical function. This helps to identify the didactical function of each content offering subsidies to user to meet the specific knowledge needs, thus facilitating learning. So the purpose of the Didactic Domain Ontology (DDO) is to provide a semantic and logic description of the work domain, which also constitutes the learning domain. The domain is described in terms of concepts, relations, and objects that are relevant for this domain, as well as the pedagogical order. The Didactic Domain Ontology (DDO) is an ontology created to define learning domains and organize contents in learning materials. This ontology is created according to the business needs, being designed one ontology for each learning domain, and uses an integrated approach of conceptual and didactical model that aims at uniting different modeling perspectives creating specific didactical domain models.

Consequently, DDO is created in a way that can guide learning in the best manner possible from the content inserted in social tools. Therefore, through of DDO, the knowledge introduced will be classified and organized not only in a domain, but also in order to help when the content is requested, being presented in an organization that assists the learner to understand and assimilate the knowledge.

B. Proposal Architecture

This section presents an architecture that gathers and organizes the components of the proposed environment as well as its ontologies, to create a semantic social collaborative environment.

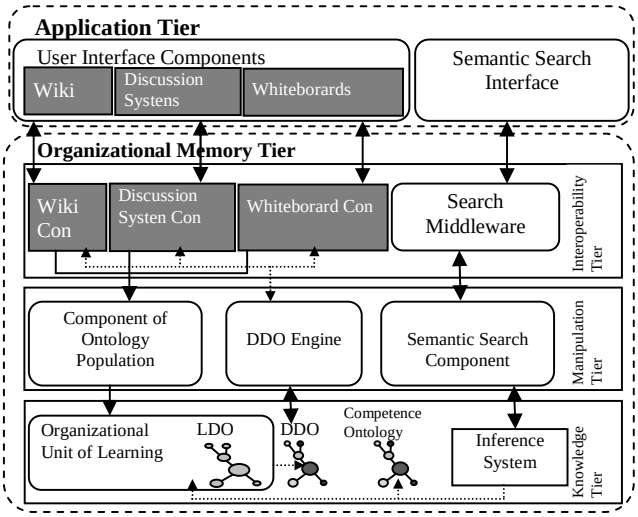

Fig. 1. Proposed Architecture

Fig. 1 provides a general overview of the proposed architecture for an organizational learning semantic environment. The architecture is subdivided into two key tiers: the application tier and the organizational memory tier, which is organized into three sub-tiers: interoperability, manipulation and knowledge.

The *Application Tier* is responsible for the user interaction and provides subsidy for the content inclusion, creation of instructional modeling domain, besides of present an interface to search in the organizational memory. This tier is composed of two components with distinct functions:

(i) user interface components: composed by the collaborative tools like wikis and whiteboards. These tools are configured according to DDO, to promote easy inserting of information respecting the domain of knowledge;

(ii) semantic search: allows semantic research to be carried out in the organizational memory based on searches for the consultation language for the Resource Description Framework (RDF), a SPARQL[1].

The *Organizational Memory Tier* is responsible for storing all knowledge generated in the application tier, as well as the manipulation of this content to organize it according to the representation defined by the organizational memory and their respective tiers: interoperability, manipulation and knowledge.

The *Interoperability Tier* provides an extensibility mechanism to allow the incorporation of new collaborative tools in the described architecture. In addition, it makes the interaction with the application tier homogeneous, providing a common knowledge representation language. This tier is composed of a collection of connectors that interact with the application tier to provide representation of the extracted knowledge from collaborative tools and submit them to lower tiers, organizing collaborative tools at the same time respecting the definitions proposed by ontologies located in knowledge tier, especially DDO. Another responsibility of interoperability tier is to interpret inferred knowledge from the lower tiers to make them available to the application tier.

The *Manipulation Tier* is responsible for the manipulation of data in the upper tiers and forwards them to the knowledge tier. This tier has three key components with different functions:

(i) DDO engine: that is responsible for providing information on the DDO structure, sending them to the collaborative tools connector to synchronize them and organize them correctly, according to what has been defined in the DDO.

(ii) Component of Ontology Populations: this component populates the LDO from the content inserted in application tier. To this it, is used the ontologies population technique [29], thus creating learning objects and units of learning, with contents generated in the application tier.

(iii) Semantic search component: organize the consultations for the inference engine and controls inferred knowledge, organizing the results, handling errors, exceptions and unexpected behaviors during execution.

The last tier of the proposed architecture is the *Knowledge Tier*. The knowledge tier is fundamental to the proposed architecture. It receives the information provided by different tools and organizes them into learning objects, and these are the base to create units of learning.

The content and material introduced in application tier is organized in units of learning. A unit of learning defines a general module of an educational process, like a course, and due to this fact, its content need be organized in a correct sequence, according to the domain. Therefore, the Organizational Unit of Learning Component uses the DDO to

[1] http://www.w3.org/TR/rdf-sparql-query/

define the correct sequence of knowledge.

Finally, in the knowledge tier there is the inference system, which carries out searches on LDO and competence ontology. As a result of this process, inferred knowledge is forwarded to the manipulation tier.

Thus, the objective of this architecture is the generation of specific knowledge objects, through the exchange of knowledge among team members, according to educational and domain models, developed by the organization, organizing knowledge to be reused and easily assimilated.

IV. FINAL CONSIDERATIONS

The work presented here focuses on the identification of the main characteristics and specific needs of a collaborative organizational environment designed to implement organizational learning in software development companies. These identified characteristics and needs are the basis for the definition of semantic organizational environment architecture.

The proposed architecture has as base on its application tier Web 2.0 tools, which helps to acquire knowledge, assisting in collaborative learning through a constructive approach.

To organize and represent the knowledge, the proposed architecture uses ontologies. Through the proposed ontologies, the domain can be specified for the business needs and can also contextualize and organize content to meet specific organization needs. Furthermore, it is proposed that knowledge be organized into learning objects and units of learning, which facilitates the organization and reuse of knowledge, helping to organizational learning. Thus, it is expected that the proposed approach can assist both in the acquisition of lessons learned and in its use, improving the organizational processes significantly through the reuse of experiences.

Considering this proposal the first step for the development of a Semantic Collaborative Environment designed to organizational learning, some issues for further research are still open such as the integration of more collaborative applications to the environment.

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