Competencies management and learning organizational memory

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Abstract

Purpose – *The purpose of this paper is to present the MEMORAe project, the goal of which is to offer an alternative to the loss of competencies and knowledge in an organization.*

Design/methodology/approach – *Within the project MEMORAe, interest was focused on the capitalization of knowledge and competencies in the context of an organization. The E-MEMORAe environment was developed based on the concept of learning organizational memory. This environment is dedicated to be used by a semantic learning organization as support for competency-based training. It is evaluated in this context.*

Findings – *In the E-MEMORAe environment, learning content is indexed by knowledge and competencies organized by means of ontologies. Learners can acquire thise knowledge and these competencies by doing different tasks, accessing different contents. In the memory, competencies are defined via the knowledge they enable to be put into practice.*

Practical implications – *It is known that some industrial communities of practice are interested in the use of E-MEMORAe.*

Originality/value – *Within the MEMORAe project, an ontology-based learning organizational memory is proposed as support for learning object retrieval by competency for competency based learning. Using such a memory enables and goes beyond organizational knowledge management. Knowledge and competencies are defined and structured to facilitate their access and their learning. This latter is also made possible thanks to the resources that they index.*

Keywords *Competences, Memory, Organizational learning*

Paper type *Research paper*

Introduction

Globalization, information and communication technologies (ICT) and innovation are the new criteria of the economic environment. The company's knowledge capital is increasingly crucial. In this context, companies must take into consideration two new risks:

1. Knowledge obsolescence with respect to its environment (technologies, competitors, markets, methods, etc.). It is thus necessary to change from a stock logic to a flow logic which could be used to set up devices for training and innovation.
2. Loss of know-how or competencies. This loss can take place in time (retirement, mutation, etc.). It can also take place through space when know-how and competencies are used only in one site but not in the other sites of the company.

A competence is a way to put into practice some knowledge in a specific context. From an educational point of view, knowledge is defined as all the notions and the principles that a person acquires through study, observation or experience which can be integrated into skills. However, studying an encyclopedia is not sufficient to gain knowledge; didactic work has to be done.

Traditional organizations are not made to learn. A great number of lessons and experience feedback are acquired then lost. Organizations acting as communities of practice facilitate their learning process. Learning can be considered as an outcome associated to acquire new competencies (Sicilia, 2005). The process of competency acquisition starts from a need in a given context. It may induce the search and the selection of relevant resources. Numerous learning resources may be used during e-learning. E-learning becomes part of a complex organizational conduct, in which the lack of required competencies trigger the search for appropriate contents (Sicilia, 2005). The large volume of information available makes it increasingly difficult to manage the information and/or knowledge required by users. The semantic web approach aims at solving this problem. It consists of considering a web in which information is given well-defined meaning, better enabling computers and people to work in cooperation (Berners-Lee *et al.*, 2001). Ontologies are the backbone of this approach; they enable the storage or exchange of resources, ontology-based reasoning or ontology-based navigation. Using ontologies clarifies the structure of knowledge. If we do not have the conceptualizations that underlie knowledge, then we do not have a vocabulary for representing knowledge; ontologies provide a means for sharing and re-using knowledge.

Organizational learning (OL) is an increasingly important area of research that examines how organizations learn and thus increase their competitive advantage, innovativeness, and effectiveness. OL requires tools facilitating knowledge acquisition, information distribution, interpretation, and organization. An organizational memory seems to be a necessity to allow organizational learning. It can be regarded as the explicit and persistent representation of knowledge and information in an organization, in order to facilitate access and re-use by members of the organization for their tasks (Dieng *et al.*, 1998). With OL, it is not necessary that learning is intentional. Indeed, an actor in an organization learns via his capacity to reach appropriate information, knowledge, resources, etc.

In the information system context, the ''semantic learning organization'' (SLO) is an emerging concept that extends the notion of the learning organization in a semantic dimension. A SLO must be considered as a learning organization in which learning activities are mediated and enhanced through a shared knowledge representation of the domain and context of the organization.

Within the MEMORAe[1] project , we were interested by the capitalization of competencies in the context of organizations, and more precisely the capitalization of resources related to these competencies. We focus particularly on the way the members of an organization can use this capitalization to get new knowledge and competencies. Our purpose is to integrate semantic web and enhanced learning approaches in a knowledge management context to promote organizational learning. To that end, we developed an environment based on the concept of learning organizational memory. This environment has been designed and evaluated, and is dedicated to be used by a SLO. It is based on a semantic web approach: learning content is indexed on knowledge and competencies organized by means of ontologies. Learners can acquire knowledge and competencies by doing different tasks (solving problems or exercises, reading examples, definitions, asking questions, etc.). In our memory, competencies are defined via the knowledge they enable to be put into practice.

In the following, we first specify relations between organizational learning and a learning organization. Then we present why and how a community of practice may be a solution to facilitate the learning process in organization. After that, we make the link between

"Globalization, information and communication technologies (ICT) and innovation are the new criteria of the economic environment."

competencies and knowledge before to present the use of organizational memory to enable organizational learning of competencies. Finally we present the MEMORAe project, founded on the concept of learning organizational memory and how it enables the link to be made between competencies, knowledge and learning objects.

Organizational learning, learning organization

According to (Sunassee and Haumant, 2004):

- organizational learning is the way in which individuals in an organization learn, from the approach they take to addressing a task-related challenge, to their understanding of how they should learn; and
- a learning organization is one in which processes are imbedded in the organizational culture that allow and encourage learning at the individual, group and organizational levels, and allow learning to be transferred between these levels.

Thus a LO must be skilled at creating, acquiring, and transferring knowledge, and at modifying its behavior to reflect knew knowledge and insights (Garvin, 1994). ''Learning organizations [. . .] purposefully [. . .] enhance organizational learning'' (Dodgson, 1993). OL refers to gaining know-how as well as to ''lessons learned'' in its negative and positive sense.

According to Nevis *et al.* (1995) and Paper and Johnson (1996), OL includes personal learning of organization employees but goes beyond it; OL is more than the sum of individual learning results.

An organization cannot learn without continuous learning by its members. Individual learning is not organizational learning until it is converted into OL. The conversion process can take place through individual and organizational memory (Chen *et al.*, 2003). The results of individual learning are captured in individuals' memories. Individual learning becomes organizational learning only when individual memory becomes part of organizational memory.

Organizational learning rarely occurs without access to organizational knowledge. In contrast to individual knowledge, organizational knowledge must be communicable, consensual, and integrated (Duncan and Weiss, 1979). According to (Chen *et al.*, 2000), being communicable means knowledge must be explicitly represented in an easily distributed and understandable form. The consensual requirement stipulates that organizational knowledge is considered valid and useful by all members. Integrated knowledge represents the requirement of a consistent, accessible, well-maintained organizational memory.

An ontology-based organizational memory seems a prerequisite to organizational learning.

Community of practice

Collaboration among a group of people is facilitated and encouraged by the presence of community. Bellah *et al.* (1985, p. 333) define community as:

> . . . a group of people who are socially interdependent, who participate together in discussion and decision making, and who share certain practices that both define the community and are nurtured by it.

The advent of web technology has led to the presence of communities in an online environment. Preece (2000) states that an online community consists of people, a shared purpose, protocols and rules that guide interactions and computer systems.

Concerning the formation of online communities, McLoughlin (1999) proposes that these communities may develop an electronic media to share resources, perspectives and ideas. The communities can then be sustained by an online social environment that is both motivating and supportive. These studies suggest that the web can be used to enable and encourage the establishment of communities of people who have never met face-to-face.

Taking a different perspective, Bosua and Scheepers (2002) maintain that the web can facilitate a community, which has been established in a face-to-face setting, by providing an electronic communication and information space.

> **"A competence is a way to put into practice some knowledge in a specific context."**

The term ''community of practice'' is a relatively recent coinage, even though the phenomenon it refers to is age-old. The concept has turned out to provide a useful perspective on knowing and learning. A growing number of people and organizations in various sectors are now focusing on communities of practice as a key to improving their performance. Communities of practice are groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly (Wenger, 2006).

Lave and Wenger (1991) and Wenger (1998) have articulated the nature of the practices from which the term ''community of practice'' derives its name:

> Such a concept of practice includes both the explicit and the tacit. It includes what is said and what is left unsaid; what is represented and what is assumed. It includes language, tools, documents, images, symbols, well-defined roles, specified criteria, codified procedures, regulations, and contracts that various practices make explicit for a variety of purposes (Wenger, 1998, p. 47).

Because ontologies reflect a ''shared world view'', codifying ''well-defined roles'', ''specified criteria'' and ''codified procedures'', they can serve as symbolic tools within a community of practice supporting communication and knowledge sharing (Domingue *et al.*, 2001). Once ontology has been constructed, a population phase uses it to describe web documents from a communal viewpoint.

Acting as a community of practice seems a prerequisite to an organization to enable its members to share experiences, knowledge and competencies:

> Provided with an ontology meeting needs of a particular community of practice, knowledge management tools can arrange knowledge assets into the predefined conceptual classes of the ontology, allowing more natural and intuitive access to knowledge (Davies *et al.*, 2003, p. 20).

Competencies and knowledge

A competence is a way to put into practice some knowledge in a specific context. Knowledge in an organization is the collection of expertise, experience, and information that individuals and workgroups use during the execution of their task (Abecker and Decker, 1999). A knowledge organization is one in which the key asset is knowledge (Conklin, 1996). An organization's knowledge is built upon experience of their human resources and the lessons they learn.

Let us specify that knowledge can be declined in various forms (Wenger *et al.*, 2002):

- Knowledge can be explicitly formalized – texts, documents multi-media.
- Knowledge can be a practice – it rests on the accumulation of experiments.
- knowledge can be tacit – all cannot be formalized. Its transmission requires suitable means: conversation, training, joint work, etc.
- Knowledge can be social – the technical know-how of a company does not rest on an individual but on the interaction of all the members of its technical community. It is while collaborating, by confronting their points of view, that these technicians create and finally hold new knowledge.
- Knowledge is dynamic, and evolves/moves in time.

We can find different definitions of the concept of competency. Meanwhile, all the definitions seem to agree on three fundamental characteristics (Harzallah and Vernadat, 2002):

1. resources;
2. context; and
3. objective.

A competency is made of resources structured into categories. We can consider three main categories of resources:

1. knowledge;
2. know-how; and
3. behaviors (Harzallah *et al.*, 2002).

Knowledge is something that we acquire and store intellectually. It concerns everything that can be learned in an education system. For example, this category is concerned with theoretical knowledge and procedural knowledge. Know-how is related to personal experience and working conditions. It is acquired by putting into practice knowledge in a specific context. Behaviors are individual characters that lead someone to act or react in a particular way under particular circumstances. They often condition the way knowledge or know-how is put into practice.

According to Baugh (1997), we can distinguish two types of competencies:

1. Hard competencies identify the basic resources that are required for performing an activity. These resources are generally expressed in terms of knowledge, skills and abilities.
2. Soft competencies correspond to personal behaviors, personal traits and motives (Woodruff, 1991), for example working with others, leadership, etc.

The competency context is related to the environment in which the competency is situated. It represents the conditions and the constraints in which competencies should be mobilized.

Competency is related to reaching a goal or to the accomplishment of one or more missions or tasks. These goals, missions or tasks constitute the objective of the competency.

Finally, acquiring competencies needs to select resources, to manage their combination and to control the way of bringing them into play.

Organizational memory, organizational learning and competencies

A competency is taken to mean the characteristic of an individual or group that is required to produce an effective organizational performance. Thus, competency is related to the underlying knowledge and skills needed to perform a role within an organization. According to Nonaka (1994), the core competencies of an organization include tacit and explicit knowledge, and should be conceived of as a mix of skills and technologies. In this context, the concepts of knowledge and competence are closely related (Lindgren and Wallstrom, 2000). Organizational memory is broadly defined as consisting of everything retrievable (Chen *et al.*, 2003). According to Stein and Zwass (1995), organizational memory is defined as ''the means by which knowledge from the past is brought to bear on present activities and may result in higher or lower levels of organizational effectiveness''. It can be regarded as the explicit and persistent representation knowledge and information in an organization, in order to facilitate their access and their re-use by the adequate members of the organization for their tasks (Dieng *et al.*, 1998). Thus, an organizational memory seems indispensable for organizational learning. An integrated organizational memory provides mechanism for compatible knowledge representation, as well as a common interface for sharing knowledge, resources and competencies.

Individual learning may be supported by making organizational memory readily accessible to an organization's members. Such a memory enhance conceptual learning, it includes organization-wide communication support, access to decision-support modeling, and computerized aids for identifying and capturing individual learning experiences (Chen *et al.*,

2003). Thus individuals may share and improve their knowledge and understanding of their problems and ideas without winding up with information overload.

A learning organizational memory: the MEMORAe project

An organization cannot make an employee learn. Learning is continuous and the choice to learn is self-determined. An environment which facilitates an organization's members learning seems essential in this context. Numerous learning resources may be used during e-learning. E-learning becomes part of a complex organizational conduct, in which the lack of required knowledge triggers the search for appropriate contents. Different approaches may be adopted to exploit such contents. They can be stored in learning object repositories and then reused, combined and adapted in different contexts. They can also be selected and organized in learning memories that are accessed directly by learners. These approaches offer goal-driven organizational learning.

Within the MEMORAe project:

- We were interested in online communities of practice using ontologies to index and share resources. These communities may have been established in a face-to-face setting or not, and currently concern academics (teachers and students).
- We focus on hard competencies and particularly knowledge resources, and the context and objective of the competency.

Within the MEMORAe project, we consider that learners attending the same training or belonging to the same organization act as communities of practice. Our goal is to let these learners access the resources of a training memory directly. Following a knowledge engineering approach, we organize the resources in a learning organizational memory based on ontologies (Abel *et al.*, 2006). In fact, it is a training memory, where training is seen as an organization. This memory is different from a classical organizational memory because its goal is to provide users with content pedagogically. This content is the result of two pieces of work:

1. the capitalization of knowledge, competencies, information and learning resources relating to the learning context; and
2. pedagogical work concerning the choice and the organization of this capitalization.

The pedagogical content is composed of the notions to learn, the links between these notions and the learning resources they index. Notions are not only chosen because they are related to the course unit, they are also the result of a reflection on the course itself. Resources have to be selected relying on pedagogical goals. The choice of their indexing terms is also related to this goal. It is not an automatic indexing. The course manager is responsible for the relevance of the links. It is not because a document treats of a notion to acquire that it will necessarily be indexed by this notion. The choice is explicit, that is to say that the document must have been evaluated as being sufficiently adapted to the learning of this notion. These choices are part of the pedagogical scenario the course manager wishes to implement.

The learning organizational memory we propose aims at facilitating knowledge organization and management for a given course or training, and at clarifying the competencies it enables people to acquire.

In order to give learners direct access to the memory, part of the instructional design work has to be made earlier. The advantage is that the memory is ready to be used by learners, provided that the pedagogical and didactical choices made earlier are acceptable.

Within the MEMORAe project, we realized two pilot applications to evaluate our propositions. The first concerns NF01, a course on algorithms and programming at the University of Technology of Compiègne, and the second concerns B31.1, a course on applied mathematics at the University of Picardy (France).

Use case

When users need to acquire a new competency, they can access the concept defining it in the ontology. A way to do this is to navigate through a concept map based on an ontology defining the organization's competencies. According to their access rights, they can visualize and load different resources. They can also continue the navigation and access knowledge to put into practice or people who work on projects requiring these competencies. In the case of accessing exchange resources (news group, e-mail), they can exchange ideas or information (externalization of tacit knowledge). Thus, learning can occur by means of these different resources, for example by:

- asking a question of the right person (the one who is described as an expert: (s)he worked on a project linked to the searched knowledge or competency, etc.);
- asking a question of everyone concerned by a subject (newsgroup);
- reading the right report, book, etc. (communication resources); and
- realizing the right exercise, problem or QCM (action resources).

The MEMORAe model

The MEMORAe model relies on the expected use of the memory: e-learning. We mainly tried to:

- determine and present the knowledge to learn and the resources describing it;
- determine and present the competencies to be acquired by means of the knowledge they put into practice; and
- offer natural and easy access to the memory contents.

For this purpose, we were interested on the one hand in ontologies to represent the competencies, the knowledge to learn and their links (definition of a common vocabulary), and on the other hand in Topic Maps (XTM, 2001) as representation formalism facilitating navigation and access to the learning resources. The ontology structure is also used to navigate among the concepts, as in a roadmap. The learner has to reach the learning resources that are appropriate for him.

Knowledge to learn and resources

According to the LTSC Working Group on Learning Object Metadata[2], learning objects (LO) are defined as any entity, digital or non-digital, which can be used, reused or referenced during technology-supported learning. Examples of technology-supported learning include computer-based training systems, interactive learning environments, intelligent computer-aided instruction systems, distance learning systems, and collaborative learning environments. Examples of learning objects include multimedia content, instructional content, learning objectives, instructional software and software tools, and persons, organizations, or events referenced during technology-supported learning.

Thus the content capitalized in the learning memory is a set of LOs, so we were interested in the learning object metadata (LOM) to index it. The LOM standards will focus on the minimal set of attributes needed to enable the LO to be managed, located, and evaluated.

The IEEE Learning Object Metadata Draft defines eight meaningful categories of descriptors[3]:

"Organizations acting as communities of practice facilitate their learning process."

1. General – groups the general information that describes LO as a whole, i.e. Identifier, Catalog, Entry, Title, Language, Description, Keyword, Coverage, Structure, and Aggregation Level.
2. LifeCycle – features related to the life cycle of the resource, like Version or Status.
3. MetaMetaData – origin and edition of the metadata.
4. Technical – this category describes the technical requirements and characteristics of the LO, i.e. format, size, location, requirement (OrComposite, Type), installation remarks, Other Platform requirement, duration.
5. Educational – this category describes the key educational or pedagogic characteristics of the LO: Interactivity Type (active, expositive, mixed document), Learning Resource Type (exercise, diagram, graph, experiment, table, slide, etc.), Interactive Level, Semantic density, Intended End User Role, Context, Typical Age Range, Difficulty, Typical Learning Time, description, Language.
6. Rights – this category describes the intellectual property rights and conditions of use of the LO.
7. Relation – this category defines the relationship between one LO and others, if any.
8. Annotation – comments on the educational use of the LO and information on when and by whom the comments were created.

Even if all these descriptors are important, we think they should not be used in such a way because they provide room for ambiguity and lack of definition. We do not agree, for example, with associating various activity types such as exercise or exam with data representations like diagram, figure or graph in the same set (Learning Resource Type). This lack of a clear interpretation is in part due to non-existence of a complete set of consistent vocabularies (Sanchez-Alonzo and Sicilia, 2005).

To navigate through the memory, the end-users (learners, teachers, etc.) need a shared vocabulary and knowledge structure. This is why we decided to model the memory with ontologies. In such ontologies, LOM categories are represented by concepts, attributes (relations between a concept and a value) or relations between concepts.

From the different ontology types defined by Van Heijst (1997), i.e. generic ontologies, domain ontologies, application ontologies and meta-ontologies, we only use the second and third categories. We have to consider two aspects for modeling the memory and building ontologies (Breuker and Muntjewerff, 1999):

1. the domain of training has its own characteristics; and
2. it must be linked to the application domain of a particular training program.

The first ontology (domain ontology) we have to specify describes the concepts of the ''training'' domain (cf. Figure 1). They can be user types (teacher, administrative), document types (book, slides for oral presentation, web page, site, etc.), and media types (text, image, audio, and video). They can also be pedagogical characteristics (activity type) and they can refer to point of view (annotation). This ontology integrates some parts of the LOM.

The second ontology (application ontology) specifies the organization of theoretical notions which are studied during training session. In the example of the B31.1 course, some notions like ''set'' or ''infinite set'' are explained. It is possible, but not mandatory, to consider ''infinite set'' and ''finite set'' as sub-concepts of the concept ''set'' and to define the relation ''has cardinality'' between the concepts ''finite set'' and ''cardinal'' (in this case they are the domain and range value of this relation). According the Ontospec method (Kassel, 2005), concepts can be specialized according to ''semantic axes''. For example, the concept ''set'' is specialized according to three axes: finite/infinite, countable/uncountable, subset/superset (cf. Figure 2).

Figure 1 Part of the domain ontology

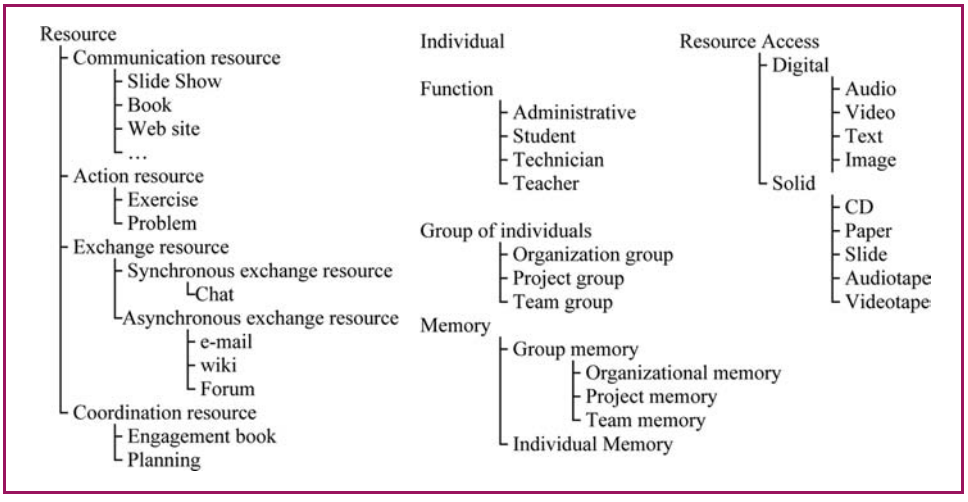
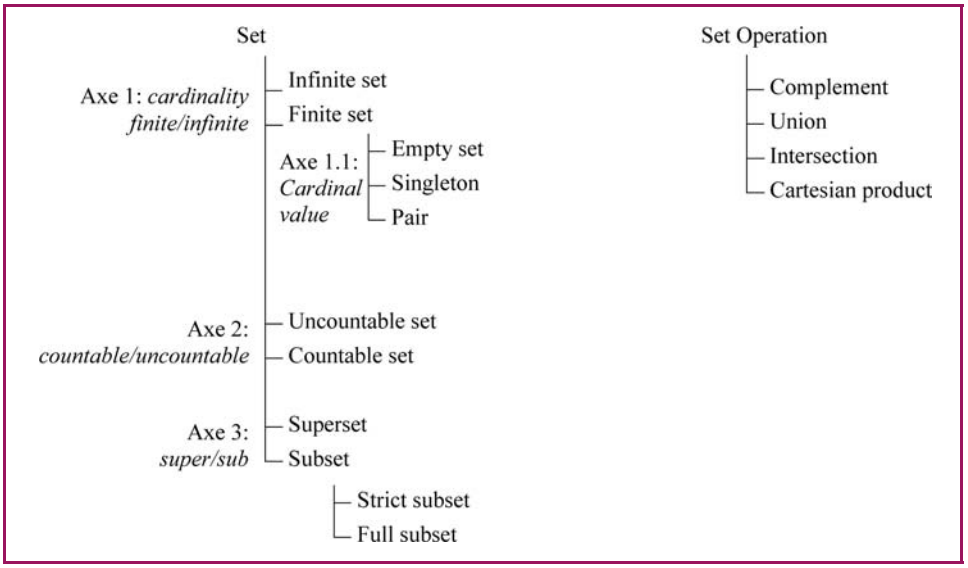


Figure 2 Specializations of the ''set'' notion



This second ontology enables us to index semantically the learning content playing the role of the keywords subject and keywords element from the Dublin Core Metadata Element Set (Dublin Core Metadata Initiative, 2006).

These ontologies are not independent; the second is necessarily attached to the first. For example, to express that a resource is an introduction to ''infinite set'' we join the two concepts ''introduction'' and ''infinite set'', which do not belong to the same ontology. Pedagogical relations like ''prerequisite'' or ''uses'' that occur between concepts of the application ontology are defined in the domain ontology. However, specific roles can belong to the application ontology (for example, for the B31.1 application, ''has-cardinality'').

Competencies

Our work of competencies modeling started from several observations:

1. Competency-based training is critical to creating and maintaining a high-performance work environment (O'Nell and Hewitt, 2005). High-quality training programs can improve

employees' performance and help them to gain the critical skills required (Ng *et al.*, 2006):

- purposeful specification of well thought out, applicable competencies requirements;
- identification of the necessary resources of individuals;
- alignment of training with competency requirements;
- the development of skill sets as well as certain knowledge and attitudes; and
- an assessment of the individual's own skills using a rating scale.

Thus an e-learning environment dedicated to such training program needs to describe formally competencies and their related information, (i.e. knowledge put into practice, learning resources) in order to enable learners to access to the rights resources. These data should be included as the part of the LO metadata (Sánchez-Alonso and Sicilia, 2005).

2. In the context of competence management, competencies are regarded as a kind of knowledge, so they must be modeled and retrieved like other knowledge asset of the memory (Vasconcelos *et al.*, 2001).
3. As for knowledge, for navigating through the memory, the end-users (learners, teachers, etc.) need a shared vocabulary and structured competencies.

Therefore we chose to model competencies by means of two ontologies:

1. domain ontology; and
2. application ontology.

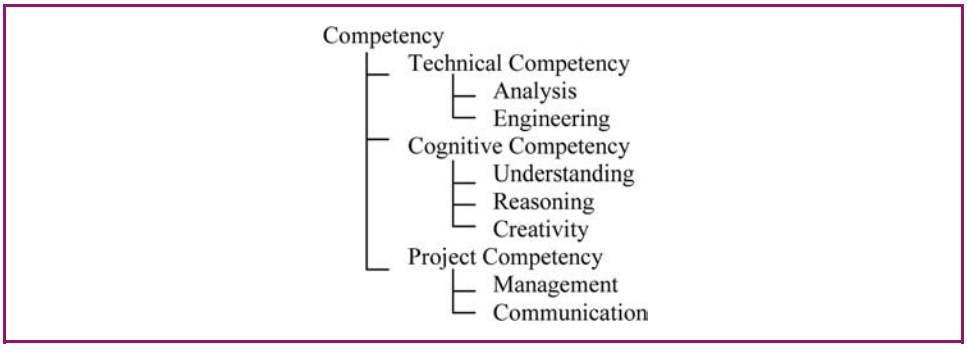
The domain ontology enables us to model application-independent competencies. It describes the subsumption relationship between competencies which are formally defined in the data model proposed by IEEE LTSC (identifier, title, description, definition, and metadata)[4]. In such an ontology (Figure 3), we find competencies defined in the taxonomy of primitive competencies (Vasconcelos *et al.*, 2003).

The second ontology (application ontology) specifies the organization of competencies that are taught during the training session. For example, competency in ''transport problem-solving method'' is a competency of ''problem-solving method''.

These ontologies are not independent; the second is necessarily attached to the first. The application ontology in fact represents a specialization of the domain ontology. For example, the competency of problem-solving method is a competence of engineering, which is a technical competency.

Finally, the competencies ontology is linked to the knowledge ontology by means of relations. For example, transport problem solving ''requires competencies of'' linear programming; linear programming ''requires competencies of'' linear algebra; linear algebra ''requires knowledge of'' matrix, which is a notion to learn.

Figure 3 Part of the competency ontology



Integration of ontologies

In the MEMORAe project the domain is the organization itself. Its corresponding ontology has to be linked to application ontologies. Figure 4 shows this integration. The root of the project ontology is MemoraObject. First, this concept must contain all the objects coming from application ontologies. We create the class ApplicationObject for that purpose and the root of any application ontology must extend this concept. Secondly, the MemoraObject concept must also contain all the objects coming from the organization ontology. The root of this ontology is called here OrganizationOntologyObject. The project defines a special class called ApplicationClass that contains all the concepts belonging to application ontology. They represent competencies and knowledge that employees have to acquire. This class extends the specific OrganizationClass containing all the generic concepts of the domain ontology.

The E-MEMORAe environment

Within the framework of MEMORAe we developed a first prototype concerning knowledge modeling: the environment E-MEMORAe[5]. Our prime objectives within E-MEMORAe were to help the users of the memory to acquire knowledge of a given course. To this end, the users have to navigate through the knowledge application ontology that is related to the course, and to access indexed learning objects thanks to this ontology.

General principle

The general principle is to propose to learners, at each step, either precise information on what they are searching for, or graphically displayed links that allow them to continue their navigation through the memory. They have no need to use the keyboard in order to formulate a request, even if the environment enables doing this.

To be more precise, the user interface (Figure 5) proposes:

- Entry points (left of the screen) allowing users to start the navigation with a given concept: an entry point provides direct access to a concept of the memory and consequently to the part of the memory dedicated to knowledge. The person who is in charge of the course has to define knowledge that (s)he considers essential.

Figure 4 Integration of ontologies

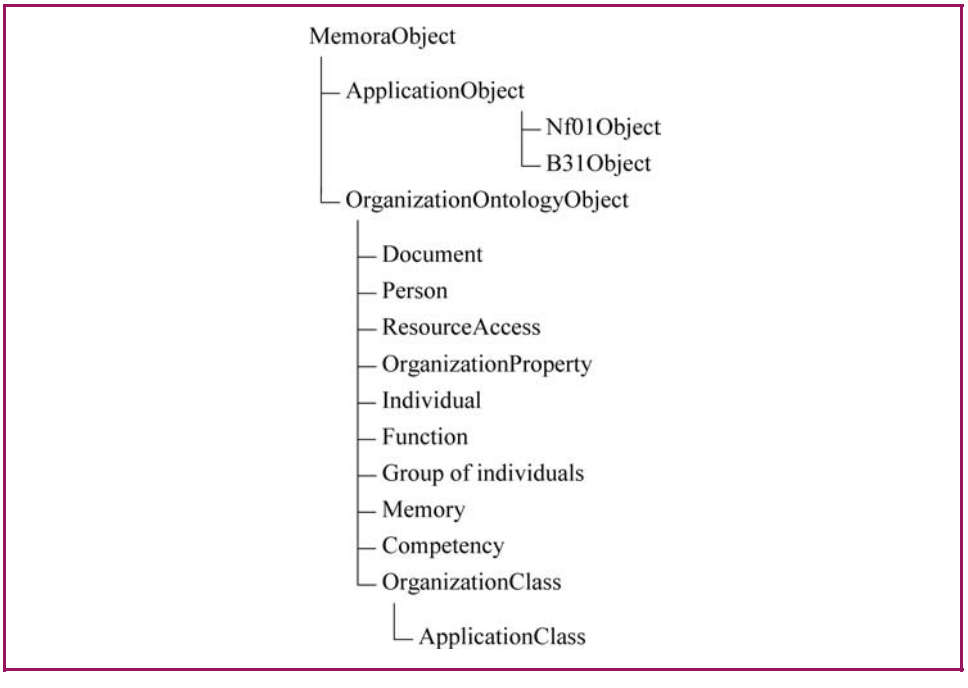
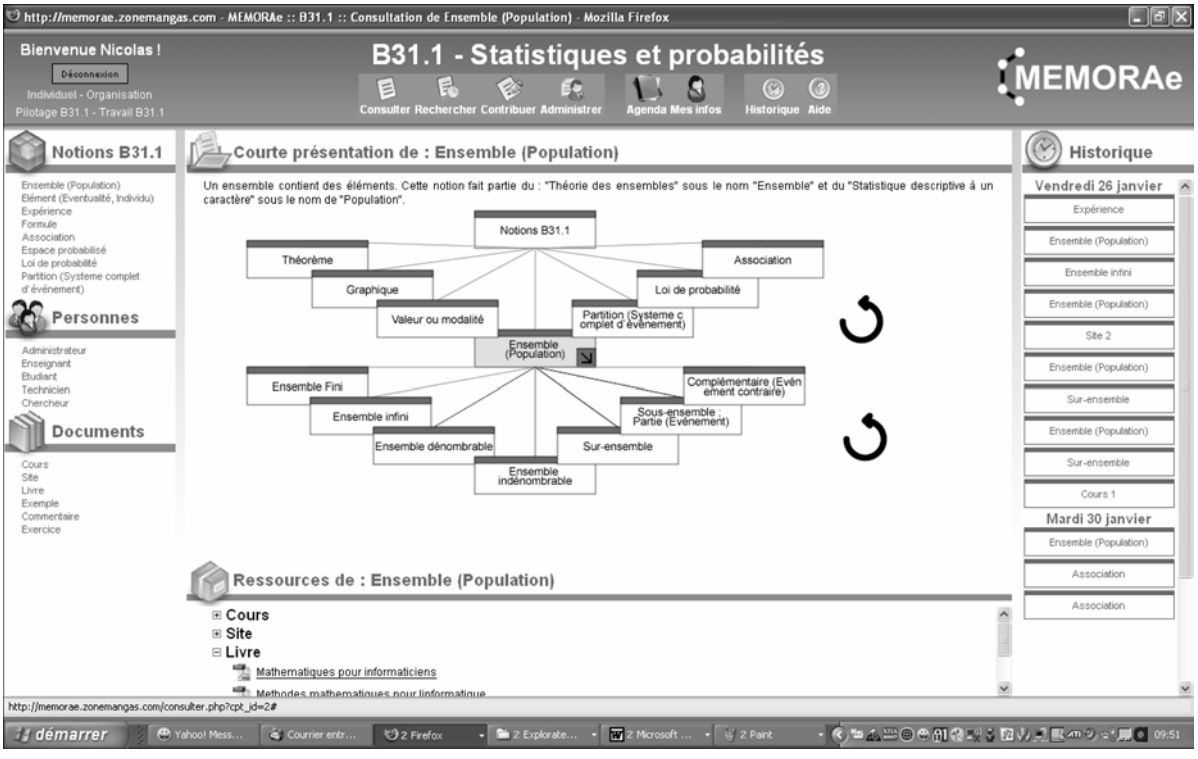


Figure 5 French navigation interface of the memory



- Learning objects related to the current concept (bottom of the screen): they are ordered by type (books, course notes, sites, examples, comments[6], etc.). Starting from the concept, an entry point or concept reached by the means of the ontology, the user can directly access associated LOs. Descriptions of these LOs help the user to choose among them.
- A short definition of the current concept: this enables the learner to get a preview of the concept and enables him (her) to decide if he has to work it or not.
- A history of the navigation: this enables learners to be reminded and made aware of the path they followed previously. Of course, learners can get back to a previously studied concept if they wants to.

Last but not least, the part of the ontology describing the current resource is displayed at the centre of the screen.

If learners wish to access to concept that is not an entry point, they have to choose the entry point that they think is the closest point to the searched notion.

Usability test

We defined a usability test[7] in order to see how students use the E-MEMORAe environment. Such a test enables the evaluation of learning and memorizing facilities, and the usability of the environment. It also enables an evaluation of the types of errors made and the satisfaction of users.

Our objective was to see how E-MEMORAe enables learners to discover new notions to learn. To verify their understanding of these notions, learners have to solve problems concerning these notions and respond to a QCM.

With this test, we can verify the pertinence of our hypothesis on the following points:

- structuring the content of training by an ontology;
- indexing LOs on ontology concepts;
- displaying the hierarchy of concepts to facilitate navigation through the LOs; and
- offering a list of entry points to give quick access to the main notions of the course.

The experiments took place at the University of Picardy and the University of Compiègne (France) and concerned students attending a Master's course in statistics or algorithms. Students from the statistics course were asked to solve a problem requiring some notions unknown to the students. Students of the algorithms course were given a QCM. They had to use the E-MEMORAe environment to discover the missing knowledge to solve the problem or to respond to the QCM.

Each student's navigation history was stored in the memory. We could then analyze the way they reached important notions and the resources they employed.

After these first experiments, we can conclude that using ontologies to index and structure the content of training is a good choice: the majority of students appreciated it. The results obtained by the students show that the majority of them were able to find the knowledge necessary to solve the problem or respond to the QCM in a limited time.

Following these good results, we are working on E-MEMORAe in order to enable visualization of the competencies ontology.

Conclusion

Globalization, information and communication technologies (ICT) and innovation, are the new criteria of the economic environment. The knowledge capital of a company is increasingly crucial. In such a context, organizational performance is highly correlated to its employees' knowledge, competencies and the way they use them to achieve work outcomes. The concept of organizational memory is born from helping organizations to manage their knowledge. However, traditional organizations are not made to learn. A great number of lessons and experience feedback is acquired then lost. Organizations acting as communities of practice facilitates their learning process.

Learning can be considered as an outcome associated with acquiring new competencies (Sicilia, 2005). The process of competency acquisition starts from a need in a given context. It may induce the search for and the selection of relevant resources. Numerous resources may be used during e-learning. Access to them is a real problem. E-learning becomes part of a complex organizational conduct. Learners have to access the right resources at the right time.

Within the MEMORAe project, we propose an ontology-based learning organizational memory as support for learning object retrieval by competency for competency based-learning. Using such a memory enables and goes beyond organizational knowledge management. Knowledge and competencies are defined and structured to facilitate access and the learning. This latter is also made possible thanks to the resources that are indexed.

In order to assess these propositions, we developed a first environment, E-MEMORAe, dedicated to be used by a semantic learning organization; it is based on the concept of

"Organizational learning is an increasingly important area of research that examines how organizations learn and thus increase their competitive advantage, innovativeness and effectiveness."

organizational memory. In such an environment, learning objects are indexed by ontologies defining knowledge and competencies to learn. Competencies refer to the knowledge they put into practice.

Until now, we have been interested of communities of academics (teachers, students) and we have realized two pilot applications to evaluate our propositions. The first concerned NF01, a course on algorithms and programming at the University of Technology of Compiègne, and the second concerns B31.1, a course on applied mathematics at the University of Picardy (France). After good results of a usability test concerning the knowledge learning processes of these communities, we are working on E-MEMORAe in order to enable the visualization of the competencies ontology. We have also had contact with communities of practice concerning textile manufacturing. They are interested in the use of E-MEMORAe.

Notes

1. In French, Mémoire organisationnelle appliquée au e-learning. MEMORAe is supported by the pole STEF of the Picardy area, France.
2. See http://ltsc.ieee.org/wg12/
3. See http://ltsc.ieee.org/wg12/files/LOM_1484_12_1_v1_Final_Draft.pdf
4. See http://ieeeltsc.org/wg20Comp/wg20rcdfolder/IEEE_1484.20.0.D3.pdf
5. See www.hds.utc.fr/memorae/
6. The comments are the only elements of the memory that users can modify as they want. An *a posteriori* control is made by the editorial committee in order to keep them or not.
7. See www.usabilis.com/gb/whatis/usability.htm

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