Chapter XVI
An Organizational Memory Tool
for E-Learning

Marie-Hélène Abel
University of Compiègne, France

ABSTRACT

Learning can be considered an outcome associated with acquiring new competencies (Sicilia, 2005) and adding new knowledge. A competence is a way to put into practice some knowledge in a specific context. The process of competency acquisition starts from a need in this specific context. It may induce the search and the selection of relevant resources. Numerous resources may be used during e-learning, their access is a real problem. Different approaches may be adopted to exploit them. This chapter describes the tool E-MEMORAE, which supports an organizational goal-driven approach based on the concept of learning organizational memory. In such a memory, ontologies are used to define knowledge that indexes resources; the capitalization and the organization of knowledge, information, and resources relating to a specific context can be realized. End-users have a direct access to the memory. The organizational environment E-MEMORAE was evaluated in the context of two courses taught at the university (algorithms, mathematics).

INTRODUCTION AND BACKGROUND

Learning can be considered an outcome associated with acquiring new competencies (Sicilia, 2005) and adding new knowledge. 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 encyclopaedia is not sufficient to get knowledge; Didactic work has to be made.

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...
An Organizational Memory Tool for E-Learning

e-learning. E-learning becomes part of a complex organizational conduct, in which lack of required competencies trigger the search for appropriate contents (Sicilia, 2005). Different approaches may be adopted to exploit such contents. They can be stored in learning objects repositories and then reused, combined and adapted in different contexts. They can also be selected and organized in learning memories that are directly accessed by learners. These approaches offer a goal-driven organizational learning.

Over the last few years, many projects aiming at building bases of learning resources, in order to share and re-use them, have been launched. These projects often rely on a network of contributors that feed the base with collaboratively controlled resources. Conversely, each contributor can benefit from resources brought by other contributors.

We can make a distinction between learning object repositories (LOR), which usually group many subject matters, and what we call “thematic resource bases” that contain resources related to only one domain.

LOR usually group all subject matters. Their scope can be restricted to one or several universities or to a country; it can also be international. If expected scope is wide, LOR are based on a network of contributors or on a consortium of institutions.

The restriction in resources related to a particular domain brings more homogeneity; resources and associated knowledge can be managed more precisely. Thus, relying on knowledge engineering techniques, Paquette (Paquette, 2001) designed knowledge and resources base on tele-learning. As in the case of repositories, the idea is also to share and re-use resources. These resources are not ready to be used by learners; instructional design work is usually needed beforehand.

On the contrary, within the MEMORÆ project (in French, Mémoire organisationnelle appliquée au e-learning) supported by the pole Systèmes et Technologies de l’Education et de la Formation (STEF) of the Picardy area, France, our goal is to let learners directly access the resources of a course memory. Following a knowledge engineering approach, we organise the resources in a learning organizational memory based on ontologies (Abel, Barry, Benayache, Chaput, Lenne, & Moulin, 2004). In fact, it is a course memory, where a course is seen as an organization. This memory is different from a classical organizational memory because its goal is to provide pedagogical users with content. This content is the result of two pieces of work: (1) the capitalization of knowledge, information, and learning resources relating to the learning context (a course unit); (2) a pedagogical work concerning the choice and the organization of this capitalization.

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 pedagogical and didactical choices made earlier are acceptable. This can therefore lead to a loss of flexibility, but we make the assumption that these choices can at least be shared by a teacher community that could act as a “community of practice” (Wenger, 1998).

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

In the following, we first specify links between competencies and knowledge. Then we specify the role of knowledge in organizations and the parallel between knowledge management and e-learning. Afterward, we introduce the project MEMORÆ, founded on the concept of learning organizational memory based on ontologies. We show how we modeled the memory. Finally, we present the organizational environment built from this model: E-MEMORÆ (http://www.hds.utc.
COMPETENCIES AND KNOWLEDGE

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

A competency is made of resources structured into categories. We can consider three main categories of resources: knowledge, know-how, behaviours (Harzallah, Leclère, & Trichet 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, procedural knowledge. Know-how is related to personal experience and working conditions. It is acquired by putting into practice knowledge in a specific context. Behaviours 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:

- **Hard competencies** identify the basic resources that require performing an activity. These resources are generally expressed in terms of knowledge, skills, and abilities.
- **Soft competencies** correspond to personal behaviours, 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.

In this chapter, we focus on hard competencies and particularly knowledge resource, context, and objective of the competency.

KNOWLEDGE AND ORGANIZATION

Knowledge in an organization is the collection of expertise, experience, and information that individuals and workgroups use during the execution of their task (Abecker, & Decker, 1999). A knowledge organisation 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. The effective management of this knowledge is addressed through research in the field of knowledge management: organizational memory. In order to share information in an organization, actors have to use common terminology, especially when they are geographically distant. It is one of the reasons why organizational memories are often based on ontologies.

Organizational Memory

According to Van Heijst, Schreiber, and Wielinga (1997), one of the attempts of knowledge management is to make sure that an organization is able to apply the right knowledge at the right place and at the right time to achieve its business goal.

Another attempt concerns the development of a knowledge policy based on business strategy. It necessitates a knowledge infrastructure to implement it and to monitor the functioning of the knowledge infrastructure (is the knowledge
Two necessary conditions for accessible knowledge are: an efficient way of finding information related to some information need, and an efficient way of investigating the “context” of information found in order to establish its relevance and reliability (Martin, 1993).

A common approach to tackle the knowledge management problem in an organization consists of designing an organizational memory (OM). Such a memory can be seen as “an explicit and persistent representation of knowledge and information in an organization, in order to facilitate their access and reuse by members of the organization for their tasks” (Rabarijaona, Dieng, Corby, & Ouaddari, 2000, p. 56). The first role of an OM is to support the growth, the transmission and the conservation of knowledge (Steels, 1993). To that end, organizational memory management is based on the following stages (Dieng, Corby, Giboin, & Ribière 1998):

- Needs detection
- Construction and structuring
- Diffusion of the contents
- Exploitation of the contents
- Evaluation of the objectives
- Maintenance and evolution of the contents

Organizational memories should comprise the knowledge of an organization collected over time (Klemke, 2000). It includes a model to describe information resources and the context in which these sources are created. It also includes knowledge in the form of personal memories of users (their knowledge, resources, etc.).

**Ontologies**

The term ontology is borrowed from philosophy, where ontology is a systematic account of existence. For artificial intelligence (AI) systems, ontology is an explicit formal specification of how to represent objects, concepts and other entities that are assumed to exist in some area of interest and the relationships that hold among them. What “exists” is that which can be represented. According to Gruber (1993) “An ontology is an explicit specification of a conceptualization.” Guarino gives precision on this definition, considering that ontologies are necessarily a partial specification of a conceptualization (Guarino & Giaretta, 1995). We can add with Gruber “an ontology is a description (like a formal specification of a program) of the concepts and relationships that can exist for an agent or a community of agents.”

Using ontologies in AI systems is important. Indeed, ontological analysis clarifies the structure of knowledge. If we don’t have the conceptualizations that underlie knowledge, then we do not have a vocabulary for representing knowledge. Another point is that they provide a means for sharing knowledge (Chandrasekaran, Josephson, & Benjamins, 1998).

Finally, an ontology is a catalog of the types of things that are assumed to exist in a domain of interest D from the perspective of a person who uses a language L for the purpose of talking about D. The types in the ontology represent the predicates, word senses, or concept and relation types of the language L when used to discuss topics in the domain D (Sowa, 2003).

According to (Van Heijst et al., 1997), we can distinguish different kinds of ontologies:

- **Domain ontology**: Represents specific conceptualizations of a domain. These representations are reusable for several applications of this domain.
- **Application ontology**: Represents domain knowledge useful for a given application. This knowledge is specific and not reusable.
- **Generic ontology**: Represents valid conceptualisations for different domains.
- **Meta-ontology**: Represents language primitives of knowledge representation.
An Organizational Memory Tool for E-Learning

KNOWLEDGE MANAGEMENT AND E-LEARNING

Currently, several approaches concern the pedagogical content management for e-learning. They are often based on the use of large sets of learning objects. A set of learning objects can be a “repository” shared by a network of actors whose goal is to reuse and adapt learning material. It can also be a “learning memory” where resources are structured and organized in order to support distance learning.

Learning object repositories (LOR) usually group all subject matters. Their scope can be restricted to one or several universities or to a country; they can also be international. If expected scope is wide, LOR are based on a network of contributors or on a consortium of institutions.

In Europe, the Alliance of Remote Instructional and Distribution Networks for Europe (ARIADNE, 2004) focuses on the share and re-use of hypermedia learning documents. These resources are stored in a “knowledge pool system” and are indexed by metadata based on the LOM (learning object metadata) standard (LOM, 2002). The re-use of these resources can be made by:

- Creating new materials from pieces of material to which the author can add new elements,
- Making a new presentation of an existing course material obtained by a rearrangement of its semantic components.

This implies that each author involved in the knowledge pool experience allows, under citation restrictions, the use and modification of the components he brings in it. Conversely, he can do the same thing with other components.

ARIADNE has thus interesting selection and access features, but one can notice that an instructional design work remains necessary to re-use the resources.

The restriction in resources related to a particular domain brings more homogeneity; resources and associated knowledge can be managed more precisely. Thus, relying on knowledge engineering techniques, Paquette (2001) designed knowledge and resources base on tele-learning. To this end they rely on task ontology, based on use cases, and on a domain ontology that allows them to better index the resources.

As in the case of repositories, the idea is also to share and re-use resources. These resources are not ready to be used by learners; an instructional design work is usually needed beforehand.

On the contrary, within the MEMOR.ae project, our goal is to let learners directly access the resources of a course memory. Following a knowledge engineering approach, we organise the resources in an organizational memory. In fact, it is a course memory, where a course is seen as an organization. It can rather be seen as a memory of concepts and resources that teachers or designers find useful in the framework of a particular course.

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 pedagogical and didactical choices made earlier are acceptable. This can therefore lead to a loss of flexibility, but we make the assumption that these choices can at least be shared by a teacher community that could act as a “community of practice” (Wenger, 1998).

In using such a course memory, the learner can access the appropriate learning activities. It can be considered a goal-driven organizational learning.

A LEARNING ORGANIZATIONAL MEMORY: THE PROJECT MEMOR.ae

The project MEMOR.ae was started from two points:
A course unit is based on knowledge and competencies it should provide, on actors (learners, instructors, trainers, course designers, administrators, etc.), and on resources of different types (definitions, exercises with or without solution, case studies, etc.) and different forms (reports, books, Web sites, etc.). In this sense, a course is an organization.

An effective organizational memory is a prerequisite for organizational learning (Balasubramanian, 1995). Indeed, both the demonstrability and usability of learning depend on the effectiveness of the organization’s memory.

Within the MEMORAe project, we propose to manage the resources and knowledge of a course by the means of a “learning organizational memory” based on ontologies (Abel et al., 2004).

**Learning Organizational Memory/ Organizational Memory**

A learning organizational memory is different from a classical organizational memory because its goal is to provide pedagogical users with content. This content is the result of two pieces of work: (1) the capitalization of knowledge, information, and resources relating to the training or course unit; (2) a 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 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. For example, with NF01, why and how to make a link between the “loop” and “array” notions?

Resources have to be selected relying on pedagogical goals. The choice of their indexing terms is related to this goal, too. 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 be necessary indexed by this notion. The choice is explicit; that is to say, the document must have been evaluated as sufficiently adapted to the learning of this notion.

These choices are part of the pedagogical scenario the course manager wants to implement. In a classical organizational memory, there is no pedagogical scenario because the objective of this kind of memory is not training.

The learning organizational memory we propose aims at facilitating knowledge organization and management for a given course or training, and at clarifying competencies it permits acquiring.

An organizational memory allows capitalizing not only on learning resources related to the contents of the course but also on information on actors themselves (specificities, background, profile, etc.). Administrative management (registration, notes, etc.) of the course can also be realised. Beyond the pedagogical content, the memory capitalizes:

- any information related to the learning environment that can be useful to users: trainers, staffs, entry form, learners, etc., and
- users’ knowledge.

**Pedagogical Content of a Learning Organizational Memory**

The pedagogical content of a learning organizational memory is mainly composed of the notions to learn, the links relating them, and the resources indexed by them. The manager of a training memory is responsible for its content, that is to say, the choice of the notions to learn and the resources indexed by these notions. In this sense, there is no course design (as it can exist in a linear course) but more precisely pedagogical content selection. The only material created is the set of notions, links, and annotations that can ac-
company them (for instance, why is this concept difficult). Resources are reused as they are.

**Notion to Learn**

The design of an e-learning application implies focus on the learner, giving him/her the means to be active, to make him/her understand the resources that are at his/her disposal, and to teach him/her how to search and use them. In knowledge engineering, a notion is any entity of thinking; it is used to structure knowledge and the perception of the world. Notions to learn are used as indexes to access documents related to them. A notion to learn can refer to several resources (giving several means to acquire it), and a resource can be referred to by several notions (giving several means to retrieve it).

Note that a digital document can be made of several parts that can be themselves indexed. It will, however, remain a document as a whole for which the author has no writing guidelines to follow.

**Learning Resources**

Learning resources are generally documents: course texts, course notes, slides, e-books, reports, books presentations, and so forth. They may also be anything useful for training (for example, software, links to Web site). Among the represented resources, some (digital resources) are stored in the memory and others are references or description to physical resources.

Resources can get accessed according to different rights. They can be private. In this case, users only store them in the memory and do not want to give other users access to them. They can be annotations, work in progress, or downloaded and not yet analyzed documents. Resources can also be semi-public or public, that is to say, shared by part or all of the users. For example, an annotation of a reader giving his/her motivated impression on a resource can help memory users choose appropriate resources. Moreover, several annotations written by different authors or relying on different notions can be attached to a same resource.

Resources can also have different status. They can be terminated and validated resources, or, on the contrary, working resources created by one or more users and therefore shared by them during the time of their realization.

**Annotations**

Our reflection on annotations started from two observations:

On one hand, when users of the memory access a notion to learn, there are faced with several resources related to this notion. The choice can be based, as it is presently, on several associated characteristics: author, resource type (book, Web site), but it also could be guided by other information such as comments or remarks on the resources.

On the other hand, the role of an organizational memory is to capitalize knowledge. It is then useful to keep track of the reasons that led a course manager to choose a resource, a notion, or a link between two notions.

We propose to take into account this information by using annotations.

In the MEMORAe project we consider that an annotation:

- Is a resource, result of an annotation action.
- Is related to a target that can be a notion to learn (concept), a link between concepts, a resource, a part of a resource, a collection of resources.
- Has one or several authors and presents its/their comments on the target. These comments are created at a given date with a precise objective and are directed to a precise audience (that can be the author himself in case of a personal annotation).
• Is not part of the target itself. It is then necessary to make a link between the target and the annotation.
• Makes sense only in its context (target, author, goal, audience).
• Can be text, graphic, voice, or illustration. Note that a target must have a representation in the memory in order to be annotated. As an annotation is a resource, it can be itself annotated. Following this conception, our notions to learn are not annotations; they are metadata. We will now see how we represent them using ontologies.

**The MEMORAe Model**

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

• Determine and present the notions to learn and resources describing these notions.
• Offer a natural and easy access to the memory contents.

For this purpose, we were interested, on the one hand, in ontologies to represent the notions 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.

**Ontologies**

For navigating through the memory, the end-users (learners, teachers, etc.) need a shared vocabulary and knowledge structured. That is why we decided to model the memory with ontologies. From the different ontology types defined by Van Heijst et al. (1997), 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 & Muntjewerff, 1999). First, the domain of training has its own characteristics. Second, it must be linked to the application domain of a particular training program. The first ontology (domain ontology) we specify describes the concepts of the « training » domain (cf. Figure 1). They can be users’ types (teacher, administrative), document types (book, slides for oral presentation, Web page, site, etc.),
An Organizational Memory Tool for E-Learning

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). Learning resources are not organized following the way recommended by the learning object metadata standard in the educational category, because we do not agree to associate various activity types, like exercise or simulation, with data representation like a diagram, figure, or graph in the same set. A description of the LOM standard can be found in the document 1484.12.1, http://ltsc.ieee.org/wg12/index.html.

The second ontology (application ontology) specifies the organization of theoretical notions that are studied during training session. In the example of 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 to 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).

These ontologies are not independent; the second one is necessarily attached to the first one. For example, to express that a document is an introduction to “infinite set,” we join the two concepts “introduction” and “infinite set” that 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”).

Topic Maps

The modeling of a training memory, which is presented here, contains three elements: two ontological parts and the way to index documents on them.

The modeling must at least allow three operations:

Figure 2. Specializations of the “set” notion

![Diagram of set specializations]

- Set operation
  - Complement
  - Union
  - Intersection
  - Cartesian product
• The reunion of two ontologies: the generic one and the application one;
• The substitution of an application ontology by another one coming from another domain;
• The attachment of document indexing on the reunion of two ontologies.

The modeling must also favor the answering to queries on the memory like:

• What are the documents (books, presentations, Web pages) that talk about, introduce, and develop a notion that appears in the training?
• What are the notions associated (pre-requisite, studied in the same time…) with a given notion?

The Choice of the Topics Maps Formalism

The choice of the formalism(s) for representing the memory is very decisive. It must go beyond the hybrid aspect of the modeling (ontology and indexing) and favor the interoperability between various tools that have to deal with the memory (edition, updater, consultation, navigation, etc.).

Two paths can be followed: either to choose the languages better adapted to the specific nature of each element of the modeling or to choose a unique language. The first choice requires a system to easily integrate data coming from the two formalisms. The advantage of the second choice is to unify the description of data. It can be valid only if this formalism allows describing some features that it is not worded for.

The second choice can be split into two parts: We can choose a formalism adapted to ontology features representation or a formalism adapted to document indexing. The main aspect of the memory and its main use influence the choice of the formalism.

Even if the indexing of the learning documents is the main aspect of the memory, it is necessary to use a formalism allowing representation of ontological elements. Several formalisms can be envisaged, but we recommend the topic maps (TM) formalism (IEC, 1999).

This formalism is useful to define and manipulate the information attached to resources. That provides a logical organization a large quantity of resources, keeping them accessible and facilitating the navigation between them. Since 2001, it has been possible to write a TM using the norm XTM 1.0 (XTM 2001) that can be considered a particular extensible markup language (XML).

The building of a TM is based on an organization of topics. Each resource is directly attached to one or more topics by an “occurrence link.” The « Association » concept allows defined roles between topics. Moreover, the TM standard allows reifying some associations in order to place them in a particular “scope.” Some resources can also be reified as a topic when it is necessary to attach other resources or data on them. In this manner, we can add annotations to resources. Annotations are resources that express a point of view on other resources.

Overall, we chose the TM formalism because it keeps a semantic level close enough to the model of our memory. With an ontology-oriented point of view, also developed in (Park, 2002), this formalism allows envisaging the important following characteristics:

• It is possible to consider some topics as generic concepts and other as concept instances.
• It is possible to consider associations, scopes, and occurrences as roles between concept topics.
• Associations have no limitation in their member number.
• The occurrence relation allows to directly attach resources to concepts (the same resource can appear in several occurrence
relations and be accessible from more than one concept).
• Relations (associations, occurrence) and concept labels can be defined inside scopes. This allows simply implementing annotations (or points of view in the memory).

To definitely adopt this formalism, we verified it was possible to take into account ontological features, mainly the relation superclass-subclass for building hierarchies of concepts.

An Example

Let’s consider the notion finite set; its definition is « a finite set is a set which has a cardinal ». It is represented by:

• three topics: finite set, set, cardinal
• Two associations: superclass-subclass (subsumption link between “finite set” and “set”), possess.

The notion “finite set” is treated on the Web site http://www.planete-maths.com/html/.

Figure 3 presents the XTM syntax of the topics map formalism corresponding to this sentence.

THE ENVIRONMENT E-MEMORAe

With the organizational environment E-MEMORAe (Abel, Benayache, Lenne, & Moulin, 2006), resources can be reached by navigating through a graphical display of the ontologies on which it relies. It integrates tools to facilitate autonomous learning.

We present this environment by using examples coming from the B31.1 application.

The User Interface

E-MEMORAe aims at helping the users of the memory acquire the notions of a given course. To this end, the users have to navigate through the application ontology that is related to the course and access the indexed resources thanks to this ontology.

The general principle is to propose to the learner, at each step, either precise information on what he is searching for or graphically displayed links that allow him to continue navigating through the memory. He has no need to use the keyboard in order to formulate a request, even if it is possible through the environment.

To be more precise, the user interface (cf. Figure 4) proposes:

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

• Resources (bottom of the screen), the contents of which are related to the current concept: They are ordered by type (books, course notes, sites, examples, comments, etc.). Starting from a notion, an entry point, or a notion reached by the means of the ontology, the user can directly access associated resources. Descriptions of these resources help the user to choose among them.

• A short definition of the current notion: The learner has a preview of the notion; he can decide if (s)he has to work it or not.

• A history of the navigation: The learner can remind and be aware of the path (s)he followed before. Of course, (s)he can get back to a previously studied notion if (s)he wants to.

• Least but not last, the part of the ontology describing the current resource is displayed at the centre of the screen.
Figure 3. Extrait XTM d’une topic map

1. `<topicMap xmlns="http://www.topicmaps.org/xtm/1.0" xmlns:xlink="http://www.w3.org/1999/xlink">`
2.   ...
3.   `<topic id="t-finite-set">`
4.   `<instanceOf>`
5.     `<topicRef xlink:href="#t-set" />`
6.   `<instanceOf>`
7.   `<baseName>`
8.     `<scope><topicRef xlink:href="#FR" /></scope>`
9.   `<baseNameString> Ensemble fini </baseNameString>`
10.  `<baseName>`
11.  `<occurrence>`
12.   `<instanceOf>`
13.     `<topicRef xlink:href="#Site" />`
14.   `<instanceOf>`
16.  `<occurrence>`
17.  `<topic id="t-Cardinal">`
18.  `<instanceOf>`
19.    `<topicRef xlink:href="#t-B31OBJECT" />`
20.  `<instanceOf>`
21.  `<baseName>`
22.    `<baseNameString> Cardinal </baseNameString>`
23.  `<baseName>`
24.  `<topic>`
25.  `<association id="A-LA001">`
26.  `<instanceOf>`
27.    `<topicRef xlink:href="#t-Possess" />`
28.  `<instanceOf>`
29.  `<membre>`
30.    `<roleSpec>`
31.      `<topicRef xlink:href="#t-set" />`
32.    `<roleSpec>`
33.      `<topicRef xlink:href="#t-finite-set" />`
34.    `<membre>`
35.      `<roleSpec>`
36.      `<topicRef xlink:href="#t-numberElement" />`
37.    `<roleSpec>`
38.      `<topicRef xlink:href="#t-Cardinal" />`
39.    `<membre>`
40. `<association>`
41.   ...
42.   `<topicMap>`
If the learner wants access to a notion that is not an entry point, he or she has to choose the entry point that he or she thinks is the closest point from the searched notion.

Learning by Exploration through the Memory

Vertical navigation allows exploration of subsumption relations and related concepts. For example, if the user wants to discover the “finite set” notion, the best entry point is “set (population).” By choosing this entry point, (s)he has access to the local taxonomy associated with the notion of set. Among the sub-concepts of “set,” (s)he can find “finite set.” By clicking on this concept, a local taxonomy centred on this new concept is displayed (cf. Figure 4). Thus the learner can browse the ontology using its taxonomic form.

Some presentation rules are used in order to help the user visually explore this hierarchical organization: The current concept C is at the centre of the screen; all the sub-concepts of C that represent more specific notions are presented; at last, the super-concept of C, which represents a more general notion, is also presented. We did not find it useful to extend this representation. Our goal was to keep it understandable.

To end with the hierarchical navigation, let us finally note that the representation uses semantic axes. In order to visualize them, we used different colours for each of these axes. At this stage, their meaning is not explicit.

Let us suppose now that the learner decides to temporarily stop the navigation and focus on a particular concept. This concept is at first described by a short definition. If the user wants to learn more on the selected notion, (s)he has access to a list of resources ordered by type. For example, Figure 4 shows that if the user wants to deepen the notion of “Finite Set”, (s)he can select among the associated resources—for example, a book entitled “Mathematics for Computer Science”—by left-clicking on the name of this resource. A description text is then displayed in a new window (cf. Figure 5). Other bibliographic information such as ISBN number, authors, publisher, and so forth are also available. When the
An Organizational Memory Tool for E-Learning

A concept can refer to concepts other than those that are displayed in the taxonomy. Access to these concepts is sometimes needed in order to understand some notions. Proximity relations (other than subsumption) are useful for that. Examples of these relations are: prerequisite-of, in-the-definition-of, suggests, and so forth. Other application-specific relations such as subset-of, has-cardinal, and so forth can also be considered. We call this kind of navigation “horizontal navigation,” in comparison with the “vertical navigation” that we considered before. These relations are accessed by right-clicking on the source concept C; a popup menu contextually displays the available relations starting from C. Let us consider one more time the case of the finite set concept (cf. Figure 4). Among the available horizontal relations, the learner can choose, for example, “prerequisite-of” and learn more about prerequisite notions such as “countable set” or “cardinal” (cf. Figure 6).

Choosing the “countable set” concept in the list of the prerequisite concepts of “finite set” allows switching back to a vertical navigation centred on this new concept of “countable set.” Finally, one can see that the navigation through the application ontology is made very easy by combining vertical (left-click) and horizontal (right-click) moves.

After each exploration action made by the learner, the history (cf. Figures 4 and 6, right frame) is actualized. This history keeps track of the path followed by the user during his (her) exploration. Of course, it is possible to go back to a previously visited notion by clicking on it in the history.

Learning by Querying the Memory

We have seen in the previous section how to access the contents of the memory by navigation (“consult menu”). It is also possible to directly access a notion by querying the memory (“Search menu”). This interface allows searching for a word in the textual data contained in the memory. The word can be all or a part of an author, notion, or resource name, or it can be included in the textual description of the notion, and so forth.

For example, Figure 7 shows the search results for the “set” word.

When choosing a notion in the search results, the user has access to the part of the taxonomy
An Organizational Memory Tool for E-Learning

Figure 6. Horizontal Navigation

Figure 7. Searching the « finite set » notion

related to this notion. He or she can continue to explore the memory horizontally or vertically (cf. learning by exploration through the memory).

ARCHITECTURE

The architecture of the E-MEMORAe environment is a three-tier architecture: PHP/MySQL, Appach, and JavaScript/HTML+SVG. This type of architecture separates the application in three levels of distinct services: presentation, treatment, and storage.

Figure 8 shows the functional architecture of the E-MEMORAe environment: one can indeed find a storage part (MySql data base), a treatment part (Topic Maps modeling, etc.), and an information presentation part.

The MEMORAe web site is accessible at the following URL: http://www.hds.utc.fr/~ememora/Site-MEMORAe/.

CONCLUSION

We presented in this chapter a goal-driven organizational approach to facilitate the search for appropriate resources to acquire new competencies. Indeed, numerous resources may be used during e-learning. Their access is a real problem. E-learning becomes part of a complex organizational conduct. Learners have to access the right resources at the right time.
This kind of problem is a problem of knowledge management, and we propose to achieve it in using the concept of learning organizational memory based on ontologies. This memory is different from a classical organizational memory because its goal is to provide pedagogical users with content. This content is the result of two pieces of work: (1) the capitalization of knowledge, information, and resources relating to the learning context (for example, a training); (2) a pedagogical work concerning the choice and the organization of this capitalization.

The opposite of the approach that is generally adopted with learning objects repositories or thematic resources bases, this course memory is bound to be directly used by learners. This implies doing an earlier part of the instructional design work. Let us note, however, that this approach is only feasible with learners having self-regulating abilities.

The E-MEMORae environment we developed is based on the use of ontologies and topic maps. It is used as a support for e-learning. The objective is to help users understand the notions starting from resources selected by teachers. The indexing of the documents is supplemented by pedagogical criteria that help the learner appreciate his or her relevance. We think that using such a memory enhances the activity and the autonomy of the learner.

We made a first evaluation of E-MEMORae with students in the framework of the B31.1 mathematics training at the University of Picardy in France and of the NF01 algorithms training at the University of Compiègne. Our objective was to see how learners could discover alone new notions to learn through E-MEMORae. In order to assess the understanding of these notions, the learners had to solve some problems related to the notions in a given time.

In the two cases, we obtained encouraging results: the majority of students solved the problem and accessed to the right notions (seen in the recorded history).

After presenting our prototype to our colleagues, we have received different demands to use E-MEMORae. We plan to assess E-MEMORae according to the teachers’ point of view.

Currently we are working on the extension of E-MEMORae in order to assess such a memory for collaborative learning, computer support for collaborative learning (Stahl, 2002). We also search partners from industry to test E-MEMORae in an organizational learning context.
REFERENCES


An Organizational Memory Tool for E-Learning


This work was previously published in Competencies in Organizational E-Learning: Concepts and Tools, edited by M. Sicilia, pp. 146-168, copyright 2007 by Information Science Publishing (an imprint of IGI Global).