An integrated approach of Intelligent Tutoring Systems and knowledge management

Amal Zouaq, Claude Frasson, Roger Nkambou

University of Montreal, UQAM
zouaq@iro.umontreal.ca
frasson@iro.umontreal.ca
nkambou.roger@uqam.ca

Abstract

As knowledge becomes a crucial asset to organization’s survival, an efficient knowledge management policy should be set up and should result into an organizational memory. Similarly, an effective eLearning program must be implemented in the organization and exploit the organizational memory to manage competence evolution. In this paper, we propose a framework that integrates knowledge management and Intelligent Tutoring Systems. This framework exploits the organization members’ collective competence and knowledge to encourage knowledge sharing and reusability across the organization. It also provides better learning sessions through the use of an Intelligent Tutoring System.

Introduction

Knowledge is the most valuable asset in an organization. These last years, the research sector and the industry have understood how crucial knowledge is to their development and concepts such as collective intelligence and collective knowledge have emerged. More and more, organizations are seeking to find ways to capture their knowledge, especially to deal with the high mobility of theirs members and employees. Similarly, organizations are more and more involved in programs of continuous education for their members, and seek to implement what is called the just-in-time, just enough learning, that is learning adapted to a specific individual at a specific moment and context and for a specific need. To capture their collective knowledge, organizations need what is called an organizational memory and effective mechanisms to retrieve and disseminate knowledge. In this context, eLearning and Intelligent Tutoring Systems (ITS) can be of great interest.

This paper is organized as follows. First, we will determine what we call knowledge in organizational settings, and then we will give a brief state of the art in the domain of organizational memories and knowledge management. We will also give a brief overview of eLearning and ITS and explain how they can benefit from the knowledge management. Finally, we will present our general architecture to manage knowledge and disseminate it across the organization and its members.

What is knowledge?

Since the antiquity, philosophers have debated about the real meaning of the word “knowledge”. According to Davenport and Prusak [6], knowledge is a fluid mix of framed experience, values, contextual information and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organizations, it often becomes embedded not only in documents or repositories but also in organizational routines, processes, practices and norms.

In the literature, there exist many categorizations of knowledge. Indeed, knowledge can be considered as declarative or procedural, as a resource or as a process, as tacit or explicit, and so on. We will not describe all these categorizations, but we will emphasize on the tacit/explicit one, as it is the most frequent one in the knowledge management literature, and as it is the basis of a famous model: the SECI model [13]. This model is of great interest as it describes the knowledge creation and transformation processes inside the organization from a tacit/explicit dimension and from an individual/collective dimension. These four processes are: internalization, externalization, socialization, and combination. More details could be found in [13]. Our aim is to build on these identified processes to propose a pertinent framework able to vehicle tacit and explicit knowledge and to reuse it when necessary. So our framework must provide means to capture and organize knowledge, to transfer knowledge and to make the explicit / tacit / individual / collective transformation possible.

The question is how an organization can measure the knowledge it possesses? How should it capitalize it? How can we transfer the explicit and tacit knowledge across the
organization? How can training benefit from this transfer? In our opinion, the answer lies in the integration of knowledge management, eLearning and intelligent tutoring systems which has become a necessity. ITS are perfectly integrated into the modern vision of a knowledge intensive organization where learning is a continuous process. We will first describe the state of the art in the domain of knowledge management and then we will summarize how we think that this integration could be realized.

**Knowledge Management and ITS: related work**

Knowledge Management (KM) as a discipline recently gained a growing interest in business settings. KM designates the entire process of discovery, acquisition, creation, dissemination, and use of knowledge, and is a primary condition to the emergence of the so called “Learning Organization” [1, 13]. KM addresses the lack of sharing knowledge among members of the organizations by encouraging the individuals to create knowledge repositories for later re-use and to participate in communities of practice [4, 14] on a voluntary base. In order to accomplish this effective knowledge management process, we think that we need a certain model of the organization which is called enterprise modeling. According to [8],

An Enterprise Model is a computational representation of the structure, activities, processes, information, resources, people, behavior, goals and constraints of a business, government, or other enterprise. It can be both descriptive and definitional - spanning what is and what should be.

So, the role of an enterprise model is to create a shareable representation of the entire organization. Its aim is to minimize ambiguity from the communication acts and dialogs inside the organization and to maximize the members understanding, hence achieving a common collective comprehension of the problems at hand and the knowledge, activities and people involved.

For the creation of such an enterprise model, many projects talked about organizational memories (OM) and emphasized the important role they play to capture and store knowledge. An OM refers to the knowledge capital accessible independently from the actors who created it [15]. This memory does not rely only on the individuals but also on the processes, tasks, rules and structures of the organization which contain also valuable experiences and apprenticeship. Many researches have been done in the domain of OM, among them FRODO [19], KnowMore [2], EXIP [12] and COMMA [10]. All these projects share a common vision: they try to model the organizational knowledge. However, no one of them uses eLearning and more specifically ITS as a mean to share knowledge inside the organization. For example, KnowMore provides contextual information delivery integrated into the business processes, whereas COMMA aims at creating a multi-agent based knowledge repository with push and pull mechanisms for knowledge retrieval. Similarly to the COMMA project, we think that we must introduce the Semantic Web concept and the ontology concept in order to realize an effective knowledge modeling. In fact, semantic web technologies are more and more involved in the creation of corporate semantic intranets. According to its inventor Tim Berners-Lee, the Semantic Web is a vision based on the idea of having data on the web usable by programs for automating, integrating and reusing purposes across various applications. How can we provide a concrete implementation of this vision inside the organization? To answer this question, we must explore two important concepts of the Semantic Web philosophy: ontologies and meta-data.

The Ontology concept has a long history in philosophy and epistemology, and it refers to the subject of existence. In the context of knowledge sharing, Gruber uses the term ontology to mean a specification of a conceptualization [11]. In more prosaic terms, ontology provides a shared vocabulary. If it is used across the organization, it means that all the actors will share a common understanding of the resources, problems, activities and so on. Whereas natural languages provide the richest way to communicate between humans, these languages lack formality and are too fuzzy. At present, and until further improvements in the domain of natural language processing, knowledge-based systems must rely on more formal languages and ontologies can be used to that purpose.

Regarding ontologies, many propositions already exist to create an ontology-based enterprise model such as the TOVE ontology [7] or the Enterprise Ontology [18]. At present, we would like to build on the TOVE model to create a feasible enterprise modeling, and more specifically, we would like to elaborate a new model starting with the organization’s ontology component [9]. Our goal is not to model all the organizational processes and activities. For the moment, we intend to work only on a subset of what constitutes an organization and we would like to focus on the organization’s resources with the vision of using this modeling for better knowledge sharing among the members of the organization and more precisely for better learning sessions. Indeed, crucial knowledge resides in the daily work, conversations, processes and documents. Organizational activities generate bunches of documents, reports, emails, etc. that are valuable resources and that recall the actors’ knowledge, experience and their evolution across time. However, this knowledge is poorly or never taken into account to characterize the knowledge capital that resides in the organization. Moreover, we think that this document-based approach is the most pragmatic and the most cost effective one if we want to implement a complete knowledge management solution aiming at a learning organization.
Existing knowledge management systems including document management systems, content management systems and group wares did not arrive yet at a convincing solution to reuse the organization’s textual resources, without speaking about other kinds of resources (audio, multimedia, etc). Their main contribution results in knowledge repositories with no linkage to the daily management and the documents it generates, lacking effective searching mechanisms. Moreover, the knowledge residing in the repositories is chunky and completely disconnected from its context (of use, of creation, etc.). We propose an alternative to this situation by first creating four types of ontologies and then structuring each important document according to these ontologies. Then we would like to reuse this infrastructure to provide more pertinent materials to an ITS.

Our knowledge management solution

The ontologies

We propose to model the organization’s documentary resources according to four types of ontologies (Figure 1).

• First, the organization ontology that builds on top of the TOVE’s one [9] intends to describe the organization’s actors, their role, and the activities they are involved in;
• Second, the domain ontology describes the field in which the organization works. We began this step by a semi-automatic concepts gathering: starting from the organization’s documents, we are able to determine the key concepts which are repeated and constantly reused. This process is cyclic and provides a first working base. Then we provide this information to a human who is then able to construct the ontology and update it with an ontology editor such as Protégé [16]. Our research in this area is ongoing;
• Third, the competence ontology identifies the competences the organization possesses and which ones could be necessary for a planned project, an activity, etc. This notion of competence appears as the cement between the documents knowledge, the organization’s members and the knowledge aim or learning objective;
• Fourth, the document ontology identifies the key parts of a document and links them to the other ontologies.

A document is fragmented into knowledge parts by its human creator. If applicable, these parts are then linked to the domain ontology and to the competence ontology, showing for example, that competence A can be achieved by reading document 1 – knowledge part 2 and document 5 – knowledge part 1. This is a simplified vision of a competence as it would probably require also an application in real settings and more reading or exercising materials (which is currently done through eLearning).

The Semantic annotations (metadata)

As you can see in the figure 1, besides the ontologies, we talk about the concept of semantic annotations or metadata. This is the second angular stone of the Semantic Web philosophy. Metadata are data about data. In a Semantic Web perspective, metadata help search engines to understand pages content and generate more accurate resource discovery. Many languages exist to model metadata; among them are RDF and OWL. If we transpose the semantic web vision to an organizational intranet, these metadata could help locate required resources in a working context or during a learning session. Moreover, metadata are not only related to the Semantic Web, the eLearning field relies also more and more on a standardized approach built on metadata, such as the SCORM standard or the IMS norms. In general, we could say that for the moment SCORM is the most widely adopted standard in eLearning as it is the result of a close collaboration between the major actors of the domain. This is why we are planning to generate metadata built on this standard and converted to RDF to remain in conformity with the semantic web vision. The adoption of SCORM as the metadata standard will allow each document and each resource of the company to become a potential learning resource, and to be reused across SCORM-compatible environments.

Knowledge management and eLearning

The eLearning and knowledge management are two domains that have evolved separately. However, organizations are currently realizing that these two domains must be aggregated and that they must link their daily activities to their eLearning policy. How can eLearning fit into the whole picture? We think that KM and e-Learning aim both at facilitating learning and competence development in organizations. Organizations that implement both knowledge management and eLearning programs generally require...
continuous competence development, and are generally characterized by knowledge-intensive activities. We believe that the integration of KM and e-Learning could be a solution to enhance job performance and individual and collective development. From an eLearning perspective, many projects tried to realize this goal but they were centered on the eLearning side and neglected the knowledge management / eLearning integration approach. The project LIP [17] appears as the closest project to ours as it tries to find the appropriate ways to create a learning organization. LIP uses an ontology-based approach to find relevant learning objects, but does not rely on an organizational memory and on the organization’s resources. LIP does not refer either to the notion of an intelligent tutoring system.

Our idea is to develop eLearning content based on the same knowledge parts that reside in our organizational memory. Moreover, we already said that organizations need a just in time, just enough learning. Our knowledge management solution must provide a need detection mechanism and match this need to the available resources according to a specific individual. This is where Intelligent Tutoring Systems play their role.

**Intelligent Tutoring Systems and the knowledge acquisition problem**

Intelligent tutoring systems have been described as having three kinds of expertise:

- Knowledge of the domain (Expert module),
- Knowledge of how to teach (Tutor module),
- Knowledge about how to diagnose the student’s level in the domain (Student Module).

One of the main problems of Intelligent Tutoring Systems in industrial settings is that the domain expertise relies heavily on a small number of experts that come from outside the organization. Their expertise doesn’t use the experience of the organization’s members which is the most valuable resource. Moreover, experts are being asked to represent their knowledge explicitly and modularly and to create explicit representations of the content and the pedagogical strategy. The explicit knowledge representation has always been a major and arduous issue in artificial intelligence programs development. In fact, we share the view of many researchers such as [4, 20] saying that we must preserve the expert’s narrative discourse when communicating knowledge because it carries out his tacit and explicit knowledge. In addition, for some organizational scholars [3], narratives and story-telling are the major means for capturing, transferring and creating organizational knowledge, and this knowledge is detected through such mechanisms. Preserving the discourse hence constitutes a kind of narratives and story-telling. As preached by the AI community, knowledge elicitation results generally in poor, chunky, and useless knowledge bites and loses all the tacit dimension of knowledge. We must then find a good balance between knowledge decomposition and the narrative discourse dimension.

Thus, the knowledge acquisition problem must not be underestimated and is the first point to think of when building an ITS. Domain knowledge is also the first point to reflect on when building an initial Organizational Memory. Because of the multiplicity of knowledge types in the organization, we would like to preserve two paths for the knowledge acquisition process.

- The first one relies on simple yet powerful evidence: most of the organization activities rely heavily on the production of documents. So our first proposition is based on the ontology-based document structuring and decomposition described in figure 1.
- The second one is a kind of soft knowledge elicitation provided on a voluntary base by the organization’s members and directed only towards the working cases, situations, problems encountered during the daily activity and the solutions found. Hence our OM would store case knowledge bases, and we should be able to use case-based reasoning to explore these bases and find new solutions if needed.

Figure 2 summarizes the knowledge acquisition process.

---

**Figure 2: Knowledge acquisition process**

In this figure, the raw documents could be any resource considered as important by its creator and could include as various documents as emails, reports, eLearning content, etc. When documents and cases are structured according to the ontologies, a SCORM-compliant semantic meta-data builder is used to create meta-data with a semi-automatic process: some information is automatically gathered from the member’s profile and other is directly required of him. At present, we use XML as the metadata format, but we would like to transform it into RDF language in order to use one of the Semantic Web languages. This could be done by an automatic transformation process.

Now that we presented our knowledge acquisition and extraction process, the second point is to think about how this knowledge will be used to enhance competence...
development across the organization. So we must tackle two other knowledge management problems:

- Knowledge storage and organization into the organizational memory;
- Knowledge dissemination across the organization.

Knowledge storage and organization

An OM must not become a simple repository. In fact, many OM grow exponentially and become overwhelmed with unnecessary information. There must exist a validation process that decides what knowledge must be recalled and which one is important to the organization’s collective memory. Indeed, the more the OM contains pertinent knowledge, the more learning sessions will be useful in concrete working situations. Drawing on Conklin [5], we suggest that there should be a short-term memory for newly created knowledge and that this knowledge must be validated before being stored in a long-term organizational memory. This validation should be two-fold: first it must rely on the members’ recommendations, and second it must use statistical data such as the reading frequency, the readers’ profiles and so on.

Now that pertinent knowledge is stored, the idea is that we would like to develop effective pull and push retrieval mechanisms. Our search engine will rely on three mechanisms: first on the ontologies and the inference power they offer, second on the document meta-data, and last but not least on the document decomposition (Figure 1) to retrieval knowledge on demand (pull mechanism). The organization’s members will be able to search the organizational memory with as various criterions as documents, people, keywords or working cases. The system will also be able to provide a push mechanism thanks to the knowledge management and eLearning integration. Indeed, we can imagine for example that a new project begins and that member A is assigned to the project. Let us assume that this project requires a competence X. Building on the member A’s profile and the knowledge linked to the competence X, the system will be able to suggest a reading list to member A with highlighted parts in the documents. If more materials are already available in the eLearning content base, a more complete learning session can be planned and deployed in the intelligent tutoring system. If no material is available for the required competence, then the system can send a report to the concerned project manager in order to emphasize this knowledge need.

Knowledge dissemination

The knowledge push mechanism is closely linked to knowledge dissemination. As previously said, reusing the members’ documents through learning sessions is certainly the best way to ensure that knowledge won’t stay volatile and will be reused across the organization. In this context, an ITS is a major tool to disseminate tacit and explicit knowledge. This ITS should be linked to two essential components: a knowledge need analyzer and an eLearning plan generator. The knowledge need analysis could be automatic or set up by a human agent. In a workplace context, this knowledge need analyzer can be a competence gap analyzer. In fact, the notion of competence is constantly present in the organization and designates the knowledge acquired in context (experience) when accomplishing working activities. This notion of competence can also be linked to the idea of a learning objective. When learning objectives are determined according to a member profile, a plan generator is then able to gather the required knowledge objects in the organizational memory. Then the ITS deploys the learning session in conformance with the generated plan. Figure 3 summarizes this process. Because of our knowledge management architecture, the member’s profile should contain all his computing activities including document reading, writing and searching, his learning sessions, the projects participation, etc. Along with our ontology-based architecture, all this information should make the system able to determine the most accurate learning activities realizing the “just enough” learning aim.

Figure 3: eLearning planning process

Communities of practice [14] are the second way to disseminate tacit and explicit knowledge and join the idea of narratives and story-telling. In a concrete manner, we would like to implement ontology-based forums related to informal discussions working groups. The interesting point about these forums is that they can be searched as any other organizational resources. For example, thanks to the linkage to the organization ontology, by simply clicking on the author of a forum message, we should be able to know who is this person, what is his or her role, what documents he or she wrote, what projects he or she was involved in, etc. At the same time, because of the linkage to the domain ontology, a message or part of a message linked to a
domain concept X could be retrieved and proposed as a reading activity in a learning session and so on.

Development state
At present, we already have a complete SCORM-compliant Intelligent Tutoring System developed, and also a content editor that uses a SCORM-compliant Metadata builder. Our experience in the eLearning domain makes us aware of the knowledge acquisition and creation bottleneck, especially when applied to an organization. Many dollars in the industry have been spent in inappropriate eLearning courses completely disconnected from the working contexts and from the resources and knowledge already available in the organization. Our proposition is to remedy to this situation through an appropriate and integrated knowledge management solution. We are currently working on the ontology development and the document structuring and decomposition. The implementation approach that we are currently adopting is based on services.

Future works
Our project aims to provide a high level modeling of the organization. Actually, we focus on the organization’s textual resources. However, we would like also to approach the non-textual ones such as graphics and multimedia. Our use of SCORM will help us realize this goal with its metadata component. It would also be interesting to handle the oral communications and dialogs such as meetings. As we already said, an organization is not only constituted by resources but also by tasks and processes. Future work may aim to enlarge our organizational modeling and to use contextual help and eLearning sessions related to the business processes and to the workflow management, hence creating a decision-support system.

References