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CHAPTER 19 - MODELING FOR KNOWLEDGE MANAGEMENT IN ORGANIZATIONS

Abstract

Knowledge Management has become in recent years a concern of most major organizations. Already, in 2002, a survey by the US Conference Board and the American Management Association had shown that 80% of the thousand largest American companies where implementing some form of knowledge management in their organizations.

Knowledge management embed concepts like “Intellectual Capital”, “Learning Organization”, “Business Intelligence”, “Process re-engineering and decision support” and “Competency Management”. It is a cross-disciplinary field using methods and technologies from cognitive science, expert systems and knowledge engineering, data and text mining, library and information sciences, document management, computer supported collaborative work (CSCW), communities of practice and organizational science. It is clear that knowledge modeling has a central role to play in such a context.

Knowledge management includes and extends traditional document or data management in many ways. Its goal is to promote the systematic identification, production, formalization, availability and sharing of knowledge in an organization, and also to increase the competencies of its personnel, rather than simply giving them information support. Knowledge management integrates the processing of higher-level knowledge, beyond raw data or factual information. It underlines the importance of principles, models, theories, processes and methods, and helps uncover the tacit knowledge of experts to make it available for learning, working and decision-making.

Because it promotes structured and higher-level knowledge, knowledge management puts much more emphasis than in the past on the knowledge and the competencies of persons working in the organization. It embeds two important processes: knowledge extraction and knowledge acquisition. *Knowledge extraction* transforms the knowledge of experts in a domain into organized information or knowledge resources that can be made available to the whole organization. *Knowledge acquisition* by people in the organization is the inverse process that transforms organizational information and knowledge into new competencies internalized by individual staff members through learning.

Knowledge modeling connects these two processes. Knowledge models, particularly ontologies for the semantic web, are used as knowledge and competencies acquisition tools by persons involved in formal or informal training activities. Knowledge modeling also helps represent use cases of a knowledge management system by describing the actors, the operations that they rule and the resources or learning objects that they use or produce while processing domain knowledge. This corresponds to activity scenarios as defined in chapter 8. Conversely, actors involved in these use cases will help test, validate or identify improvements and extensions to the knowledge model or the ontology of a domain.

This chapter presents three applications of Knowledge Modeling using the MOT representation language and tools. These applications were performed by the LICEF team in partnership with different organizations. The first one is a project with a large company that aims to create a knowledge management environment to access technical information distributed in 30 different document bases. The second one focuses on the transfer of expertise supported by co-modeling a domain of expertise through collaboration between experts and novices. The third one uses knowledge modeling to describe the processes, the actors and the resources in a typical school, in order to identify the ICT tools that could help best support the organization in its activities.

19.1 BUILDING A KNOWLEDGE MANAGEMENT ENVIRONMENT IN A LARGE COMPANY

The transfer and retention of knowledge is a major challenge within organizations, especially when key resources leave at retirement. A large organization like Hydro-Quebec (HQ) is no exception especially because of the needs created by huge staff mobility and the great number of departures for retirement.

To avoid the lost of knowledge and ensure the continuation of its services, Hydro-Quebec uses Information and Communication Technologies (ICT) tools and methods for the transfer of knowledge. When the intention of an expert to retire is confirmed, one strategy is to transfer of knowledge to a new person, termed "novice" by co-modeling the expert's knowledge. Another strategy is to put in place a knowledge management system facilitating the transfer of information between future retirees and their replacements. The first strategy will be presented in the next section. We now focus on the second one.

Technical Information Management Project

The use of the MOT graphical language at Hydro-Québec and other organizations over years has indicated its user-friendliness demanding a low learning curve. The models produced are available for non-specialists in computers in an interoperable format that can be adapted to the terminology and needs of users. Furthermore, the MOT+ software has the possibility to export ontological models to the standard OWL-DL ontology format. This is considered important asset, for the management of knowledge in this organization.

These facts have helped to refine the initial strategy and its implementation plan for the company. A project called GIT on the management of technical Information (Imbeault 2007) is under development to enhance the knowledge and knowhow of Hydro-Quebec. It is financed by the company, with the following goals:

- To develop methods and tools to formally represent the knowledge of various fields of expertise;
- To develop robust applications and user-friendly interfaces, well adapted to the users and their needs;

- To facilitate the tracing process and access to resources in an industrial context to meet the needs of the enterprise.

The first step of this project is conducted at the Automatic Production Unit covering five disciplines in automation with high technical content, central for the core mission of the company. In particular, it plans to reduce difficulties related to many aspects: the access to technical information; their dispersion in the organization in 30 different document and data bases; the flow of information between the actors involved in the activities in the field and finally to the integration of the new employees in the organization. The methodologies and tools that are used to are those developed in the Canadian LORNET research network http://www.lornet.org/, managed at LICEF and funded by the Natural Sciences and Engineering Research Council of Canada (NSERC).

They use heavily the Semantic Web technologies presented in chapter 10. Ontology-based systems support a focused and personalized access to information. This approach allows federated search of information that is scattered in different systems, giving the impression to the user of using a single resource bank. Moreover, the use of ontologies facilitates the sharing of information between the actors involved in work processes through shared interfaces and monitoring facilities.

Tools involved in the project

Several tools are provided for the implementation of this project. Most of these tools are components issued from the TELOS operating system that has been presented in chapter 15. Some tools will be adapted to the requirements and needs of Hydro-Quebec for this project.

More specifically, two technologies based on the MOT graphical language are used to model the knowledge: domain ontologies and executable scenario processes. The integration of ontological models and scenario models in a single approach provides access to interoperable tools and methods to guide enterprises in the whole process of representation of semantic knowledge.

The following tools are involved in the GIT project:

- The **Knowledge Editor** (MOT+) is used by a designer to model quickly the knowledge and expertise in a semi-formal way (see chapter 14). Thereafter, using this tool, any expert can easily modify or add precisions to this semi-formal level of representation. In addition, this model serves as a basis to define the main classes and properties of the field ontology built with the **Ontology Editor**.
- The **Ontology Editor** presented in chapter 10 is used to produce the ontology model that describes knowledge of the domain, here Automatic Production. An example of such a domain model is shown in Figure 19.1. It exports the graph to a corresponding OWL-XML format. This formal knowledge model of the domain of expertise enables computer agents to process the knowledge. The domain ontology is the backbone of the **Knowledge Base** that contains semantic references by the ontology to the resources stored in the document and data bases, in way explained in chapter 11.
- The **Semantic Annotator** is the tool that allows the designer and other users, such as specialists in document management, to enter facts about technical information resources in the knowledge base. It is a web-based tool facilitating the entry of information in a collaborative way.
- The **Scenario Editor** is used for modeling the multi-actor processes' scenarios or workflow, together with the resources required by the activities in each processes. It uses a formalism that can be interpreted by a machine. The model on Figure 19.2 shows such a scenario modeling interactions between human actors and machine operations that must be coordinated to perform a task.

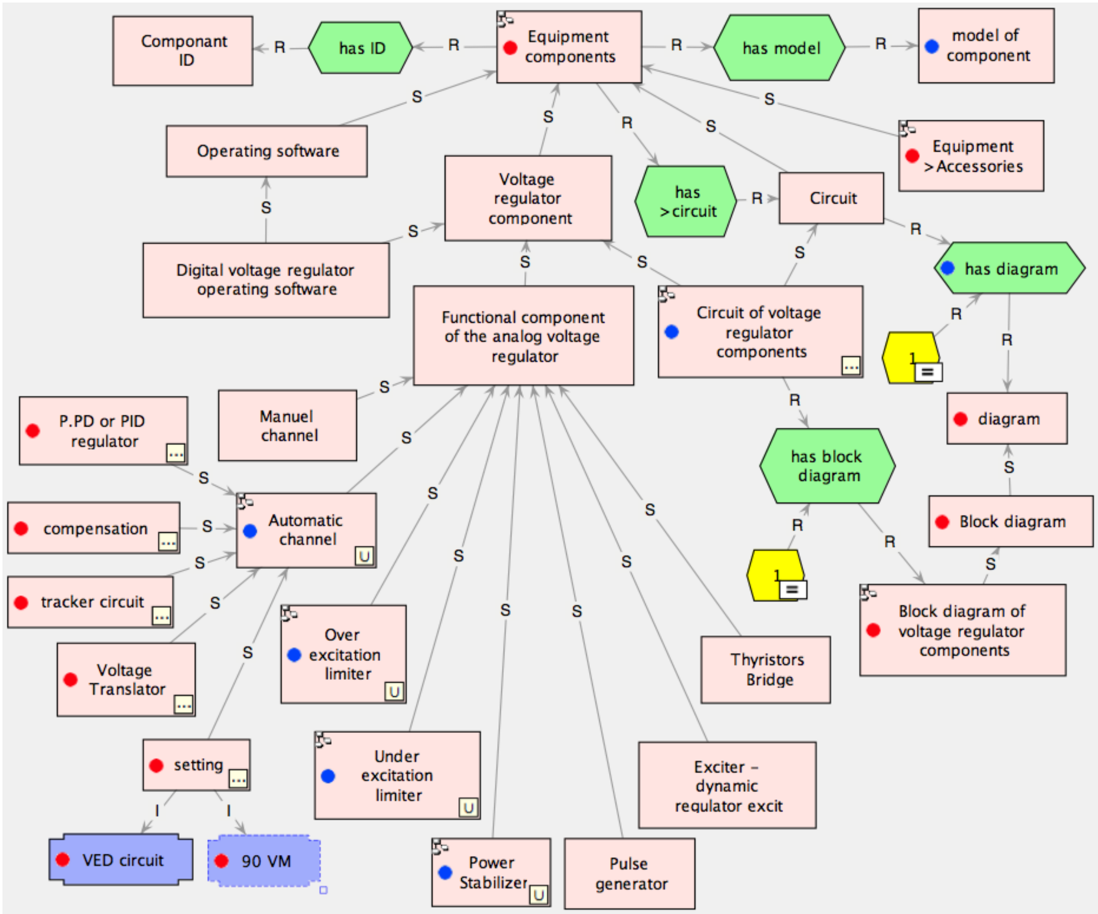

Figure 19.1: Part of the Automatic Production Ontology

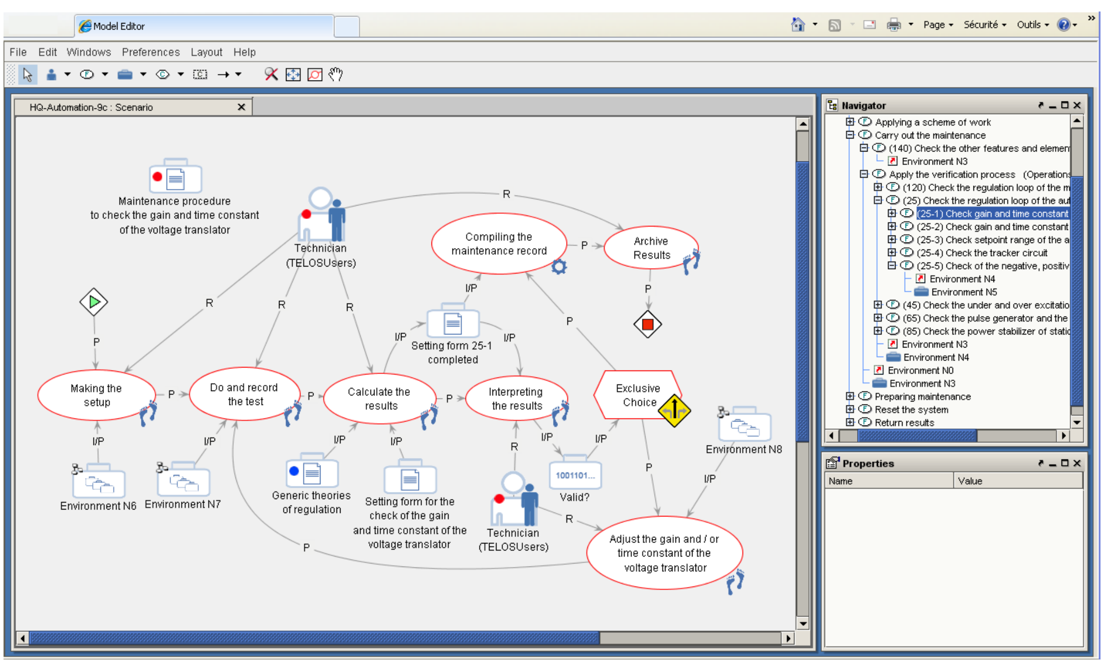

Figure 19.2: Part of the Preventive Maintenance Process

- Once the scenario is defined in a model, its **Execution** software monitors the process to support and assist people to share the information and collaborate to achieve the tasks and activities in each process.
- The **Inference Engine** can make inferences from the logical rules outlined in the domain ontology about facts entered in the **Semantic Annotator**. Any search in the **Knowledge Base** for information resources needs to pass through a request to the **Inference Engine.**
- The **Operating System** coordinates all the tools and ensures their interoperability and communication. It provides resource management, to run the tools and support the communication between the various equipments involved in the platform. It is responsible for controlling access to resources from the work processes in execution.

Implementing a Methodology

Humans are at the heart of this project and the implementation of the solution depends entirely on them. The computer systems and tools are there to support the process and make the task more systematic and effective. Figure 19.3 illustrates the process of implementing the methodology in a specific area of expertise. This scenario is a formal model showing the orchestration of the Actors and their activities, tools, and resources.

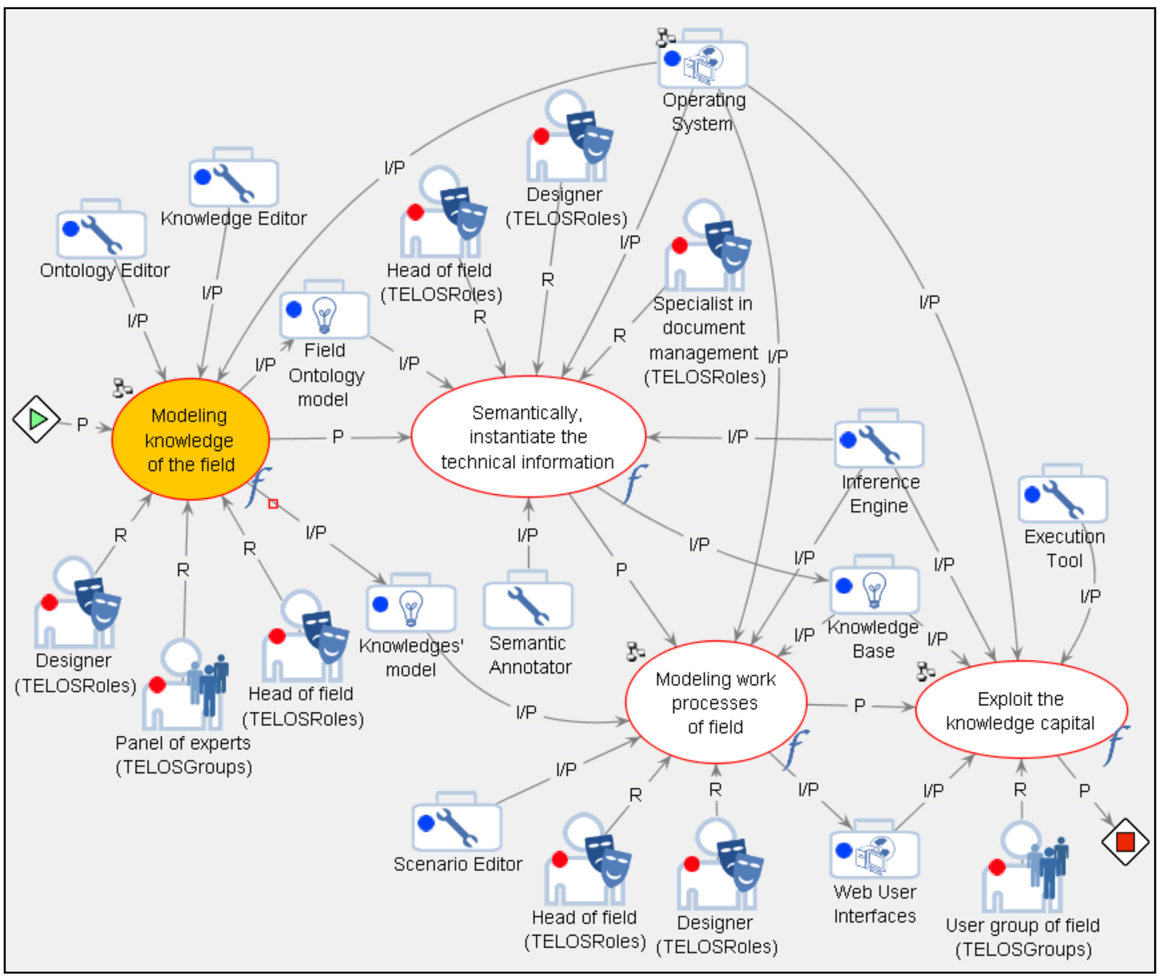

Figure 19.3 - Process of implementing the methodology in organization

In the first step, using the Knowledge Editor and the Ontology Editor, the designer meets a panel of expert and the manager to build and validate the semi formal knowledge model of the multi-actor process and the formal ontology model of the target field or domain.

In the second step, in collaboration with the specialist in document management, the designer uses the Semantic Annotator to ensure that any appropriate technical support resources are well referenced by the domain ontology. For this, the designer instantiates the ontology concepts and theirs properties with the real resources (facts) distributed in many document management systems actually in place in the enterprise. The gateways with these management systems are made by the Operating system. The result of this step is a Knowledge Base that is validated by a domain specialist.

In the next step, the designer uses the Scenario Editor to produce an executable model of the working process (scenario) based on the semi formal knowledge model issued from the first step. He also describes the technical resources necessary to perform the tasks of all actors involved, by linking them to the appropriate element in the Knowledge Base. The designer can control the specific modalities of implementation of the multi-actor process and he can also insert some automatic operations in the process to interact with software already in place in the company.

In the last step, the users interact with the working process through a graphical web interface generated from the scenario by the Execution Tool. Using this interface, they have access to the resources needed for each task and they also have the means to interact with other users involved in the process. Through other web interfaces, the users can make semantic requests to the Knowledge Base to find any referenced information. The Inference Engine tool guides this semantic search.

In summary this process aims to develop methods for the extraction, classification and operationalization of the knowledge contained in a specific domain of expertise, in the form of process-based multi-actor workflows. During the processes, users will assess the applications produced and suggest improvements to the general approach. Eventually, a validated knowledge management process will be embodied in an Web-based environment.

From a technological point of view, recent developments in the Semantic Web, including the work within the LORNET research network, ensure that the semantic approach proposed in the GIT project is feasible. More specifically, two distinctive elements can contribute greatly to the success of a semantic approach in an industrial environment:

- The use of a visual language and user-friendly tools accessible to all users;
- An integrated semantic access to intuitive and engaging interfaces, maximizing the usability of these tools.

By using interoperable standard formats like OWL-DL and multi-actor workflow scenarios, the solution is more easily integrated in an organization’s technological architecture and perfectly suited to future technological developments that are always in progress.

This project aims to lay the foundation for knowledge management implementation processes that can be used in later phases of the GIT project at Hydro-Québec, or more generally for Semantic Web applications in other organization.

19.2 TRANSFER OF EXPERTISE IN ORGANIZATIONS THROUGH CO-MODELING OF KNOWLEDGE[1]

Another strategy, experimented by a team at the LICEF Research Center in a few organizations. This strategy is based on small groups of expert and novice employees that co-construct a graphical representation of their tacit professional knowledge using the MOT knowledge editor.

[1] The projects reported in this section were conducted under the direction of Josianne Basque, regular researcher at the LICEF Research Center.

After a first analysis of the theoretical underpinnings of the proposed strategy (Basque & Pudelko, 2004) and some exploratory observations of the potential of knowledge modeling for expertise transfer in a large public organization (Basque, Imbeault, Pudelko, & Léonard, 2004), the team collected data in the context of two action-research studies in workplace settings. The first one was conducted in a large governmental organization and implied three different groups of workers (Basque & Pudelko, 2008), while the second one was conducted in three SMEs in the manufacturing sector (Basque, Desjardins, Pudelko, & Léonard, 2008).

In this section, a distinction between two types of expertise transfer is first made, followed by a presentation of the strategy experimented and of some findings drawn from data collected during the studies.

Knowledge co-modeling using visual tools

Since 1999, in the various projects through the Training Institute of Hydro Quebec and the Trans-energy division, several training onthe MISA Instructional Engineering Method (Paquette 2003) and its MOT modeling tools have been provided to designers and trainers of the company. Moreover, since September 2001, LICEF helped developed a strategy to ensure a transfer of knowledge and skills of experts (technicians, engineers, managers) using the MOT+ modeling software presented in the first part of this book. This software was progressively updated to meet some specific needs of Hydro Quebec. At the beginning, this approach, called knowledge co-modeling, was used with specialized human resources of the Division of Equipment. It was afterwards gradually used in other divisions. More specifically, between 2004 and 2006, the knowledge modeling language and tool has been used successfully to represent knowledge from various experts within the automatic production division, with the specific goal of transferring knowledge from experts to novices

In the first knowledge co-modeling strategy used, pairs consisting of an expert and a novice, model jointly the knowledge in front of a computer equipped with MOT. They represent and link together concepts, principles, procedures and facts related to a specific aspect of the work done by an expert in the organization. This process helps to preserve the expertise of the organization, including the transfer to novices. Also, the product of co-modeling, the models and other related documents are stored by a document management system. Thereafter, the models can be consulted as references for novices who can maintain or adapt them from their own experience of work.

According to a bulletin issued in October 2007 Hydro-Quebec, this process has yielded tangible results that were confirmed by an auditing firm. It offers to the participants a process of empowerment to receive and transmit information. This bulletin cites Robert Lapointe, Director of Human Resources Management at the Hydro-Quebec, Human Resources and Shared Services:

> *"We have been examining a dozen profiles of jobs, especially in Technical Information, we realize that the process allowed for learning and rapid uptake of specialist expertise. When there was a sharing problem between the expert and the learner, it could assume some responsibilities and take over when the expert would do something else. This resulted in a good success rate of securing certain jobs"*

While knowledge co-modeling has proven useful to help novices catch up fast on experts' main knowledge, it is also true that after experts retire, novices need to come back to processes and knowledge's from which their understanding depend.

Types of Expertise Transfer

We need first to distinguish between a "product-oriented" and a "process-oriented" approach to knowledge management, Basque et al. (2008) considered that two types of expertise transfer can be put in place in organizations, which they call Type I and Type II.

Type I Expertise Transfer occurs when workers interact with each other in a more or less formal manner. In this *process-oriented approach*, knowledge is considered *"tied to the person who developed it and is shared mainly through person-to-person contact"* (Apostolou et al., 2000, p. 2), and technology is used to help people communicate, collaborate and negotiate meaning.

Type II Expertise Transfer occurs when workers consult documents describing some part of the organizational knowledge. In this *product-oriented approach*, technology is used mainly to capture expert knowledge and eventually to store it in an "institutional memory".

The collaborative knowledge co-modeling strategy reported here can be used to support the two types of expertise transfer. As a process-oriented strategy, it promotes expertise transfer during the joint construction of the knowledge model by experts and novices. Through the interaction with experts, novices construct actively their own strategic professional knowledge. As a product-oriented strategy, collaborative knowledge modeling aims at capturing the tacit knowledge of the experts in a graphical semi-formal model (see chapter 16), which will be eventually made available to other employees or will be transformed in a more formal representation, such as an ontology, and will then serve to elaborate an "intelligent" and user-friendly knowledge management system that can eventually be queried in natural language.

In product-oriented type II transfers, co-modeling groups may be composed entirely of experts. However, even in these cases, the LICEF team favors a mix of expertise, since novices are likely to support and broaden the elicitation process regarding expert knowledge through their specialized and informed interventions about the targeted domain. On the one hand, they are motivated to develop their own skills within the domain and, on the other hand, they necessarily possess more skills related to the domain than do knowledge engineers from the outside.

The primary objective of our research and the experimental procedures were designed to respond primarily to the objective of transferring expertise through the co-construction of knowledge models, although we did not exclude the possibility that the resulting models could also serve the objectives of a product-oriented type II transfer. Furthermore, it was found, during the sessions, that the participants spontaneously adopted a product-oriented approach, expressed through their concerns regarding the quality of the models produced and their usability among other employees. Clearly, there is a need for the organization to clearly distinguish between the objectives of the two different co-modeling strategies.

The Co-Modeling Strategy

The procedure used to implement the co-modeling strategy in organizations includes different steps that can be operationalized differently depending of the goal and the context of the project. The MOT model of Figure 19.4 illustrates the main generic steps.

- ***Specify the domain to model.*** In a company, the specification of the target domain usually stems from managers' priorities. A systematic methodology can be used to identify, at a high-level, the most critical knowledge in the organization (Ermine, Boughzala, and Tounkara 2006). At this phase, it is also important that head managers specify the type of expertise transfer they want to implement in the organization (Type I and/or Type II).
- ***Selecting participants.*** Groups of less than five participants are recommended. Experts can be workers near retirement possessing strategic knowledge or individuals who possess rare knowledge, which are usually explicitly recognized as experts by their peers. Novices are not necessarily new staff: they can be employees who recently changed position within the organization or individuals who need to extend their knowledge on some work processes to be able to substitute other employees at times. In addition, criteria other than degree of expertise need to be considered to select participants: availability, willingness to share knowledge, familiarity with visual representations, etc.

Moreover, participants need to be well informed of the goal and process of the knowledge modeling strategy and be clearly willing to become involved in the activity.

- ***Train participants to knowledge modeling.*** Training will differ according to the role assigned to the participants involved in the project. If they are to manipulate MOT in order to revise or maintain the knowledge models after the guided co-knowledge modeling activity, training relative to the MOT software and formalism is necessary. In this case, a two-day session followed by individual and group consultations with the instructor has shown to be effective for basic training. Otherwise, participants' training to the MOT software can be limited to a brief presentation of the typologies used in MOT complemented with a summary sheet. Participants become quite easily and naturally familiar with the MOT language simply by observing how the knowledge-modeling specialist manipulates the software and uses the MOT formalism and semantic grammar.

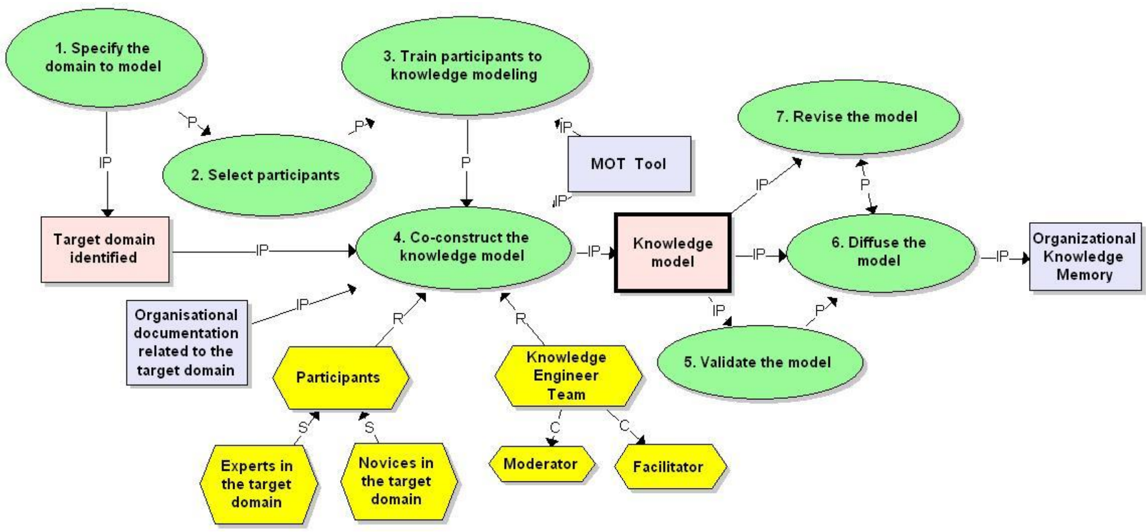

Figure 19.4 - Procedural model of the co-modeling strategy to support transfer of expertise in *organizations*

- ***Co-construct the knowledge model.*** The duration of the sessions can vary depending on the scope of the target field and the availability of the participants. In the studies reported, an intensive three-day session was put in place, which allows participants to elaborate a global, relatively stable and consensual initial representation of the field. Additional work may be required in order to add details or to extend the scope of the model.

  Two knowledge-modeling specialists worked with groups of 2 to 5 persons. The first one (the moderator) interviews participants in order to elicit overtly their knowledge, while the other one (the facilitator) manipulates the software and creates the map, which is projected on the wall.

  Prior to the session, the moderator read some documentation supplied by experts, so that he can familiarize himself with the terminology and main aspects of the target domain. He can even develop a sketchy first-level model, which will be suggested to participants in order to accelerate the knowledge modeling process and stimulate discussion at the beginning of the session.

  Some decisions should be made at the outset of the session and re-examined throughout the process: type of model that should be developed, level of specificity in the elicitation of the knowledge (developing breadth-first or depth-first?), appropriate level of granularity, etc. Participants are invited to be specific and consistent when labeling knowledge objects, and careful attention is paid to redundancy. At any given moment during the session, the knowledge model can be restructured if participants feel that it should be.

- ***Validate the knowledge model.*** Once the first version of the model is produced, a validation can be performed by one or more experts who participated in the session and/or peer experts involved in the field. It can be useful to intertwine this validation process with the participants' real work practices: while "instantiating" the knowledge represented in the model based on actual work situations, modifications to the knowledge model can be more easily identified. Electronic documents or URLs can also be attached to knowledge objects in order to provide them with a more detailed and contextual meaning. Moreover, the participants can present their co-constructed knowledge model to their managers and colleagues. This can act as a means of promoting their work, as well as allowing them to deepen their own comprehension of the model and thus supporting the validation process.
- ***Implement the model.*** If a model has been produced with the objective of a Type II transfer, an implementation strategy must be developed, including access rights management, interfacing with the organization's documents and databases, data security, etc. As explained in chapter 14, a transformation of the semi-formal model to an ontology format should be evaluated.
- ***Revise the model.*** Once constructed, a knowledge model can and must evolve to reflect the on-going development of individual and organizational knowledge. It is then important to update the model on a regular basis. This task can be performed by individuals with a mandate and (preferably) a group of people endowed with a sufficient level of expertise in the field, while also being familiar with the representational language.

Participants' perceptions of knowledge transfer and elicitation

Data collected in the two action-research studies (Basque & Pudelko, 2008; Basque et al., 2008) included interviews with participants before and after the 3-day knowledge modeling session, successive versions of the knowledge model elaborated during the session, screen- and audio-captured of the modelling session and researchers' observation notes during meetings with the coordinators of the activity in the settings. Because of limited space, we report only partial results related to participants' perceptions of the effect of the strategy on the knowledge construction process in novices and on the knowledge elicitation process by the experts.

The co-modeling process using MOT was well appreciated by most participants. Both the overall strategy and the modeling language were considered adequate in terms of the objectives. The participants recognized that the process was quite cognitively demanding. The feeling of cognitive effort experienced by participants was related to the necessity of providing precise knowledge explanations, in particular, for "decomposing" knowledge originally considered by experts as impossible or even futile to decompose further.

Since the representational strategy of participating organizations involved constructing models of the type "method and technique" explained in Chapter 3, the focus from the outset was on representing actions (procedures), which were then associated with resources and products (in the form of concepts) and strategic and conditional knowledge in the form of principles guiding and regulating these actions. Thus, it can be said that the representational property of MOT allowed the participants to focus on actions. When representing an action as a "knowledge object", then it can be decomposed into sub-actions (with the C link) or specialized into different manners to perform this action or into sub-classes of actions (with the S link). The P link (Precedence) can be used to represent sequences between actions.

This representation technique is particularly suitable for expert knowledge, whose structure can thus be reproduced. Indeed, research in cognitive psychology(Chi, Glaser, & Farr, 1988; Chi, Glaser, & Rees, 1982; Ericsson & Charness, 1994; Glaser, 1986; Schmidt & Boshuizen, 1993; Sternberg, 1997) has shown that expert knowledge is structured in the form of mental models in which the various components are closely intertwined, uneasily accessible by consciousness, and therefore difficult to communicate verbally. Experts' mental models imply much procedural knowledge (the know-how), along with knowledge on explicit conditions of its applicability known as conditional or strategic knowledge (the know-when and the know-why), and object schemata which can be instantiated at will (the know-what or declarative knowledge). The novice and the expert then have a useful means for representing their field work as their own procedural model.

This characteristic of the representational language can also bring the novice to interrogate the expert during the co-construction of the knowledge model, the concepts and principles linked to procedures in the model acting as anchors for interaction. Co-modeling generates many discussions, some of which are very lively, involving problems experienced by novices in their recent work. These discussions led some novices to find solutions to these problems on their own and even propose concrete solutions for improving the professional practices of their team. Model definition consists therefore not only in recreating existing knowledge but also, from an individual and organizational point of view, in creating new knowledge.

Novices related how they had become aware of the preferred practices of their organization and how they were able to use this information in their subsequent work. One participant described his meta-cognitive learning experience by explaining how he now approaches work-related problems "through a different lens." In one organization, a few weeks after the experiment, a novice participant was required to complete a job similar to the one modeled and found it much easier because of the learning acquired during the co-modeling process.

A notable result is that even for the experts, the co-modeling process appears to have contributed to the integration and deepening of their expertise. Thus, although no special attention was made by experts regarding the possibility of their acquiring new knowledge during the co-modeling sessions (they mainly saw themselves as "providers of information"), all experts declared during follow-up interviews that they had "seen" something new or better "understood" their way of proceeding or "dealing" with problems. This confirms that the co-modeling process enabled them to use their existing knowledge about actions as objects in the construction of new knowledge models, a process which is also known as "reflective practice" (Schön, 1983, Sternberg, 1999).

Overall, all participants considered that the models produced were satisfactory and adequately represented their area of expertise, given the relatively short time spent in the activity, and despite that the models were considered still incomplete at the end of the three-day co-modeling sessions. They found that the models were not mere repetitions or pooling of knowledge already documented in the organization, but that they were true creations that provided a new perspective on the expertise required for the targeted fields.

The research reported here indicates that co-modeling using the MOT representation language and tools has great potential as a strategy for transferring expertise between experts and non-experts, since it encourages the explanation of tacit expert knowledge and the construction of knowledge by experts and novices alike during the co-modeling process.

But the results also indicate that to fully benefit from this strategy, participants must feel enabled to use the co-modeling process and the following discussions to explain and, at times, self-explain their knowledge. In this type of strategy, then, modeling is seen as a means rather than an end in itself.

However, it seems that participating organizations did initially grasp the full potential of the strategy as a process-oriented type I transfer of expertise. Some researchers, such as Sveiby (2001), emphasize the different types of knowledge transfer/integration that should be considered in implementing a true knowledge management process within a company. The author indicates that, typically, it is the strategy of establishing an organizational memory that retains most of the attention, to the point where some people equate this strategy with an overall process of knowledge management.

Our data indicate that this was also true for the project's partner companies whose representations and expectations were oriented toward a product-oriented type II transfer. A notable result of the research carried out by Basque and her colleagues is therefore that, despite the participants' product-oriented initial focus many of the comments collected indicate that the main potential of co-modeling, as it was experienced by the participants, was to allow also a process-oriented knowledge transfer occurring during the group modeling sessions themselves.

It is therefore necessary for organizations to recognize the value of this process, not only as a Type II strategy, but also as a Type I strategy, and that they integrate it within their overall strategy of knowledge management.

19.3 MODELLING A COMPUTERIZED SCHOOL

This section present another aspect of modeling for knowledge management in organizations. Here the organization, in fact a high school, is modeled in its main processes, the actors and the documents they consult or produce, in order to help the school management introduce computers and ICT to support its functions. The project was one of the early applications of the MOT modeling methodology, conducted between 1994 and 1998 by a LICEF team (Basque et al. 1998), in two secondary schools as part of the project École informatisée clef en main (The Turnkey Computerized School) developed for Québec's Ministry of Education.

Background of the approach

The project resulted in the elaboration of a model for the computerized school and a generic model for the integration of information and communication technology (ICT) in schools. Together, the models presented here can serve as a framework for helping schools to make choices appropriate to their specific needs in terms of implementation of ICT, whether as part of teaching and learning activities, educational management activities, or resource document management activities. They process can also be adapted to other kinds of organizations.

By "computerized school" we do not mean an idealized, monolithic vision of ICT in Québec schools, but a systemic and adaptable vision of the various potential uses of ICT in a typical school "rethought" in its entirety and taking into account all of its complexity.

In this perspective, a school can be regarded as an organization in which various stakeholders or actors (students, teachers, non-teaching professionals, managers, school board members, parents, etc.) receive, access, process, manipulate, produce, and communicate information in carrying out various activities such as teaching, learning, and managing. These processes are regulated by a number of principles (pedagogical or managerial) and are implemented using various tools. ICTs, as such, represent a potential for facilitating, enriching, and rethinking how these processes are implemented. They can act as catalysts for redefining the various activities that take place in these kinds of organizations.

The computerized school model was guided by a systemic approach to school management. Under this approach, the school is seen as a system which is part of a larger system and which contains interrelated subsystems. It is therefore important not only to identify the processes of the school but also to specify the links between these processes.

The development of the model was divided into three phases: a graphic representation, a text description of the various components, and a multimedia version incorporating both the graphic and text descriptions.

Graphic model of the school

A large-scale graphic model consisting of four levels of nested sub-models was developed using MOT. The model contains three types of objects:

- School processes are represented by procedures;
- Stakeholders or Actors regulating or implementing these processes are represented by principles. Actors can be the various categories of people involved in a school (students, teachers, administrators, professionals, etc.);
- The inputs and product of the school processes are represented by concepts. These include printed documents, electronic documents, and computer equipment, as well as the tools that are used to perform the processes (inputs) or that are produced during the execution of the processes (products).

A fourth object type is not part of the proposed model but can be used to adapt the model to a particular school situation. For example, users may want to identify the word processor used in their school (Word, WordPerfect, etc.). They can add this information by instantiating the input "word processor" by a fact-type symbol representing one of the versions of Word or WordPerfect. One could also instantiate procedures to a fact representing a particular process in a school, or instantiate actors to particular people or categories of people in the school.

There are five relation types between these objects.

- Composition links are used to establish a hierarchy of school processes. This hierarchy consists of four levels: 0, 1, 2, and 3 as shown on figure 19.5
- Regulation links connect actors to the processes they "regulate" or for which they are "responsible." For example, "Student" regulates the process "Learning."
- Assistance links, represented by the letter A, connect a actor to a process, indicating that the actor participates in the execution of the processes as an assistant or helper. In Figure 19.6, the actor "Teacher" assists the actor "Student" in the process "Learning."
- Input/product links connect an input or a product to a process. Figure 19.7 shows the inputs for the process "Learning."

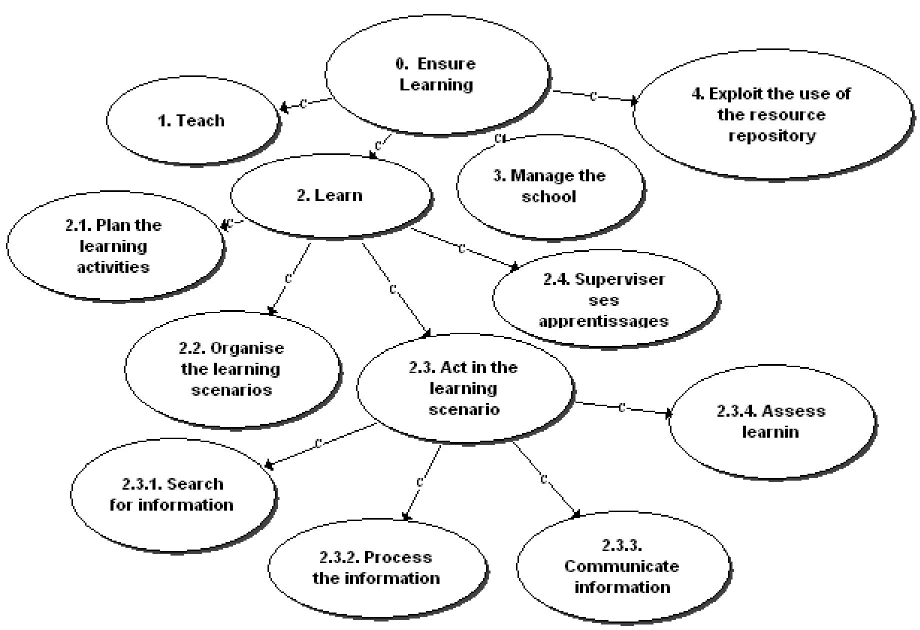

Figure 19.5 – Hierarchy of school processes

Figure 19.5 shows part of the four levels of the task model for School processes.

- Level 0 represents the most general level, i.e. the school's mission, simply identified as to "Ensure learning."
- Level 1 consists of four main processes that contribute to achieving this mission, i.e. “Teach,” “Learn,” “Manage the school,” and “Exploit the use of the resource repository (the multimedia center).”
- At Level 2 of the hierarchy, each process is divided into sub-processes. For example, the process “Learning” is divided into four sub-processes, labeled from 2.1 to 2.4.
- At Level 3, each of the Level 2 sub-processes is divided into tasks. A total of 63 tasks are defined in the model.

Figure 19.6 shows the main stakeholders (actors) and the inputs to one of the process : « Learn ».

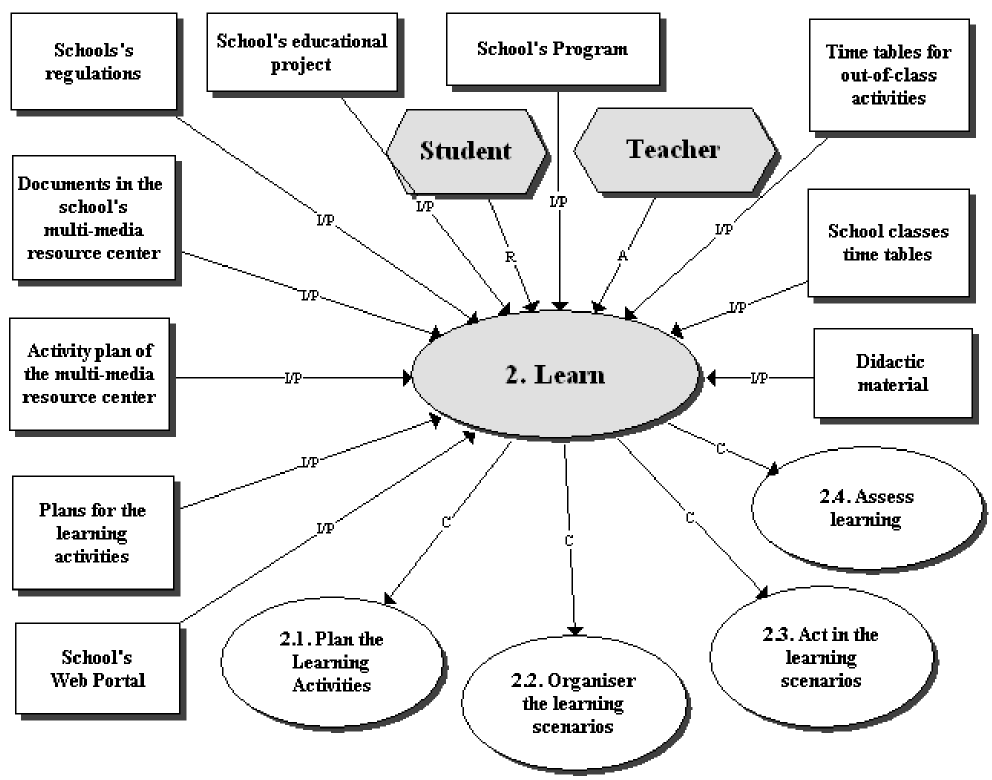

Figure 19. 6 – Actors and inputs of the process "Learning"

Figure 19.7 illustrates the input and products of task 2.4.1, « Self-learner evaluation of assistance needs during learning», a sub-process of process 2.4.

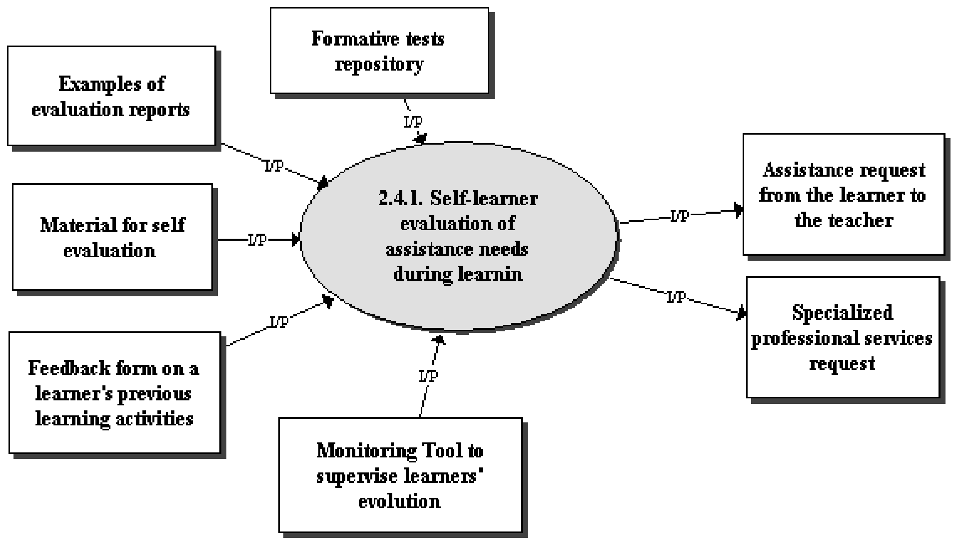

Figure 19.7 – Inputs and products of a terminal task (Level 3)

Figure 19.8 shows part of the hierarchy of tools. Specialization links connect two objects of the same type, one being a "sort of" the other. The first is therefore more specific than the second. The arrow proceeds from the more specific object to the more general one.

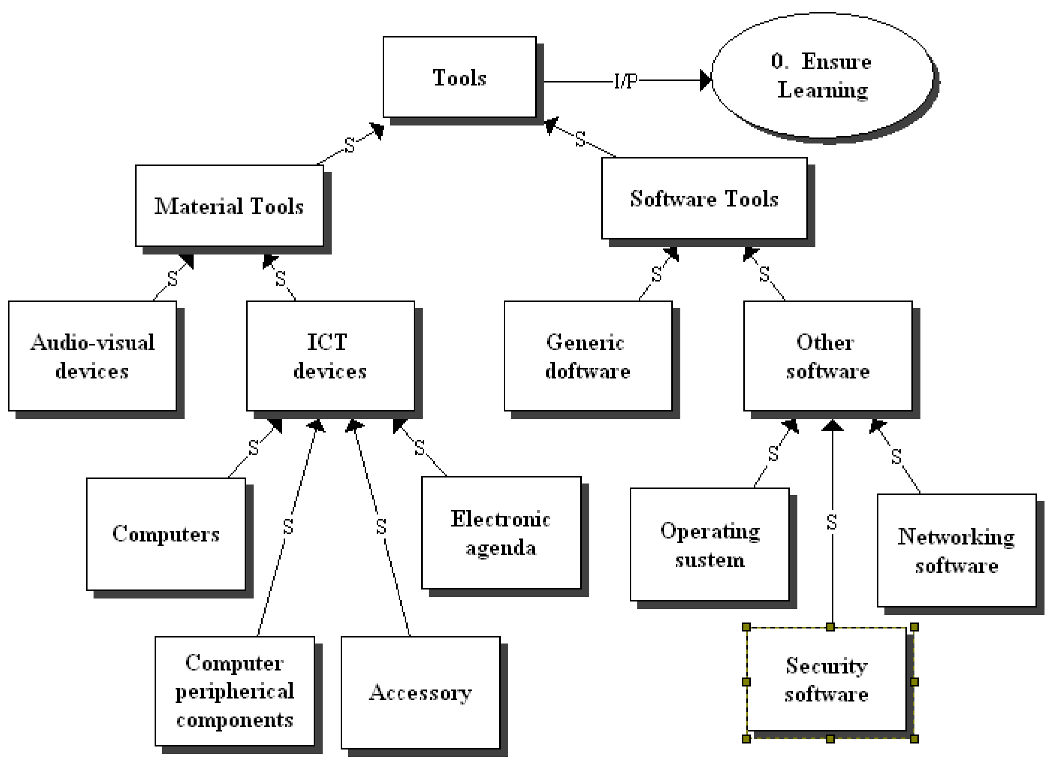

Figure 19.8 – Hiérarchy of tools used in the Computerized schools

The graphic model for a computerized school consists of 84 processes, over 300 inputs and products, and up to 10 categories of actors. Given the scale of the model, certain conventions regarding its interpretation needed to be established:

- All inputs/products and actors of a process are “inherited” at a lower level. The concept of inheritance increases the readability of graphs and decreases their redundancy. When reading a graph, therefore, it is important to identify the inputs/products and actors that appear at a higher level. The reader will notice, for example, that inputs of the type “‘generic software” (e.g. word processing, spreadsheet, e-mail, graphics, browser, and presentation software) appear at Level 0 of the hierarchy (under the input “Tools”) since these software tools can be used for all school processes. Other software tools that have a more specific use appear only at the level of tasks (Level 3).
- Inputs/products are defined in generic terms. In ontology terminology, they are classes, not individual objects. Thus, the actual name of a technological tool or generic software is not mentioned in the graph. For example, the term "word processor" is used rather than naming a specific software such as “Word 2007”.
- Objects contained in several graphs are identified by a red dot, indicating that they are repeated and cross-referenced. In MOT, by selecting the object and then "Next Reference" in the "View" menu, all graphs containing that object can be displayed one by one. All objects linked to a particular object can also be viewed by carrying out a proximity search on a new page of the model. To do this, you first select the referenced object and then “Insert neighbors” in the Edit menu.

Text and Media Versions of the model

The graphic model is supplemented by text descriptions in the form of records for each process, sub-process, and task. Each record provides a definition of the process, sub-process, or task. It offers a brief overview of how ICT can help support the process. It lists the most important inputs (including computer tools) and products of the process, and identifies the actor(s) who execute the process or assist in its implementation. The following is an example of a such a record.

2.4.1 Student self-evaluation of needs	
Description This task allows students to recognize difficulties faced at school and to identify available sources of in-school or out-of-school help. Difficulties may be cognitive (understanding, need for tutoring), emotional, or physical. Students can draw upon supplementary learning assessment activities from a bank of formative tests to verify their understanding or acquisition of new knowledge and skills. Using the formative assessment report, corrected evaluation material, and their own learning assessment record, students analyze their needs and submit requests for help from available resources and/or for professional consultation.	
ICT Contribution The bank of formative tests can be in electronic form, making it possible to identify the most appropriate tests for each student. Electronic mail offers students a more discreet method for seeking sources of help than by telephone or through personal visits to the office. The school's Web site can also be an important source of information in this regard. As well, a browser will allow students to seek information on the Internet that can help them to better manage their learning experience.	
Inputs • Corrected learning evaluation material • Bank of formative tests • Formative assessment report • Learning assessment record • Learning assessment software	Products • Student's help request form to teacher • Request for professional consultation
Actors **Responsibility:** Student **Assistants:** Teacher, professional staff	

In addition to records describing processes and tasks, other records deal more specifically with the various categories of tools identified in the model and provide, for each category, examples of existing tools.

Once the graphic and text versions of the model were completed, a more user-friendly and school-appropriate multimedia version was developed based on the model. This software is named PISTE: Pistes d'intégration systémique des TIC à l'école (paths for systemic integration of ICT in schools). This version includes inputs and inherited outputs; however, it is intended for consultation purposes only, i.e. it is not "adaptable," unlike the MOT model, which can be instantiated to the particularities of a school.

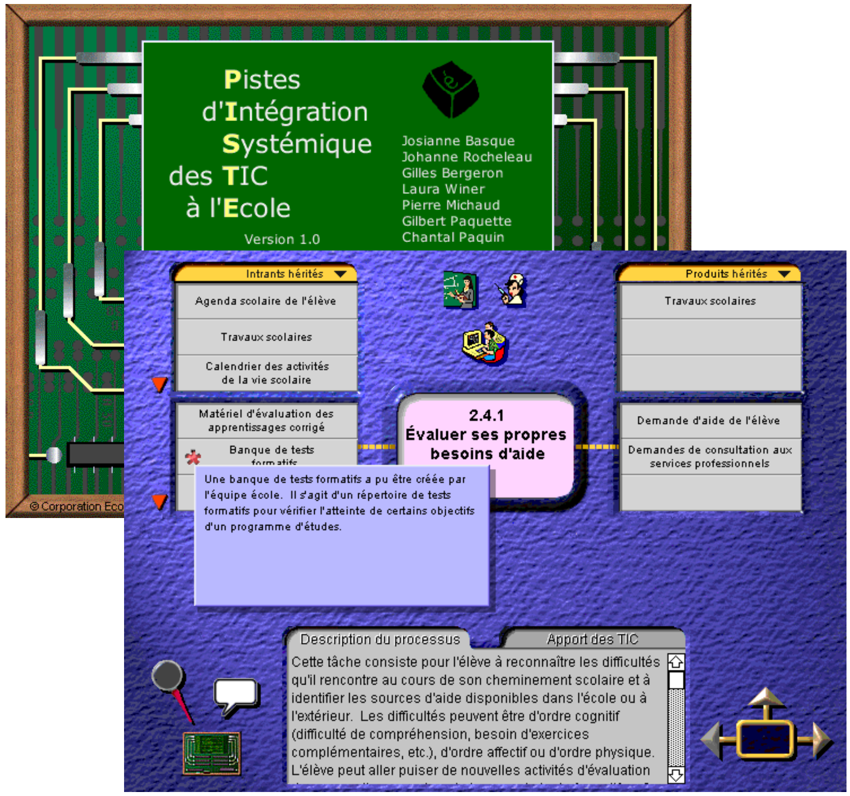

Figure 19.9 – Multimedia version of the model

Proposed use of the model

Schools can use the model to develop or regularly revise their ICT implementation plan. Indeed, the model offers a holistic and integrated approach to the typical processes that take place in a school, as well as an overview of the potential uses of various technological tools. Consequently, each school can select the processes, sub-processes, or tasks they consider priorities in their ICT plan. As well, the model can easily provide a snapshot of the many potential uses of a particular tool in the overall processes of a school in such a way as to maximize the effectiveness of the tool.

The model can also provide a snapshot of the computerization of a school's processes at any given moment or a snapshot of its computerization objectives. Indeed, the word "adaptable" in the model's title suggests that schools can make changes to the graphic version of the model as they see fit. Schools can thus omit, add, or change the names of objects or the names of relations between objects of the model to reflect as closely as possible their individual needs. Schools can even add levels to the model if they feel that certain tasks need to be further sub-divided.

Conclusion to Chapter 19

In this chapter, we have presented three wide-scale projects of knowledge management in organizations using the modeling technique discussed in the previous chapters. The first one uses visual modeling to plan the development of an ontology-driven access to a large company technical information bases. The second one emphasizes the use of co-modeling between experts and novices in various organizations as a way to transfer knowledge between co-modellers and develop the organization's memory. The third one models the generic processes in a school in order to plan the integration of ICT support to its main learning support activities.

Despite their differences, these applications of modeling have much in common. In all three projects, we have built the models first to understand the domain, then to deepen our understanding, better integrate and systematically identify the important knowledge objects and their relationships. We then used the models to provide or build resources to support the knowledge management processes. The MOT model of figure 19.10 shows the role of modeling in a cycle of knowledge acquisition and use, which is fundamental in any innovation process within an organization.

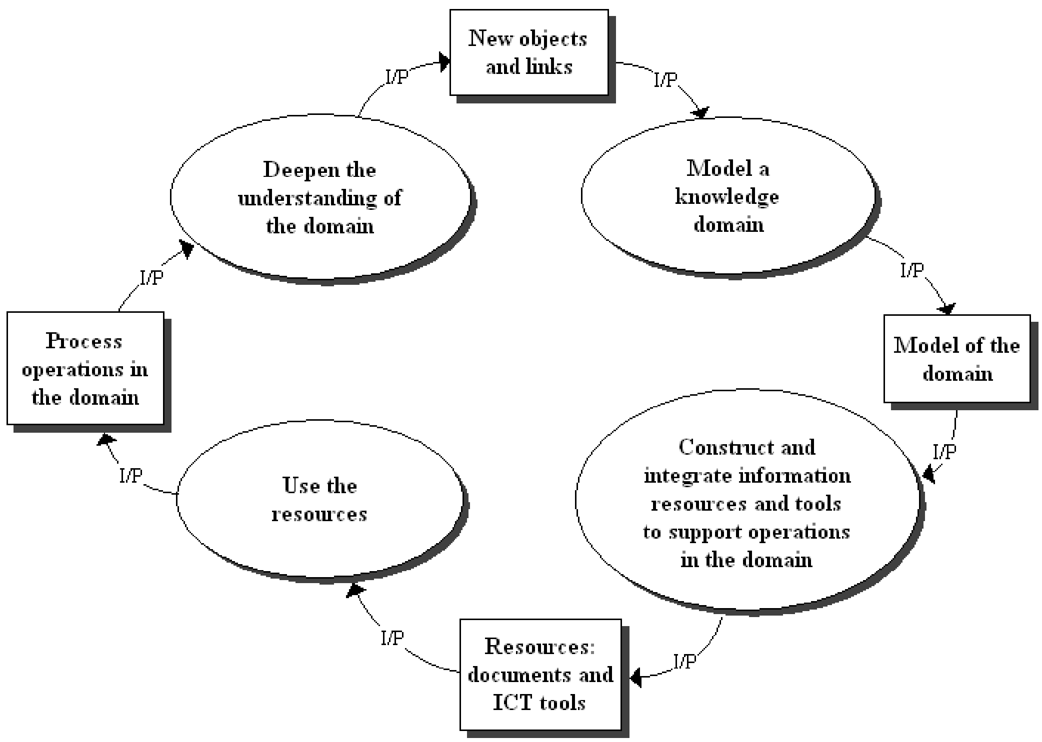

Figure 9.20 - Modeling and tools

A domain's model serves to construct the resources needed to support the operations described in that model. The model facilitates the definition of these resources (tools, documents, services, etc.) by specifying who provides them, who uses them, and in which processes or operations.

Once constructed, these resources are used by the actors for whom they are intended to carry out their various functions in the domain, for the transfer of expertise, the acquisition of competencies, or the management of an organization's work processes.

Monitoring how a domain is processed using these resources allows us not only to validate the model, but also to discover new objects and new links that can lead to a better modeling of the domain. Such a meta-method for research and development has obvious applications for many other domains than the ones presented here.

References

Apostolou, D., Mentzas, G., Young, R., & Abecker, A. (2000). *Consolidating the product versus process approaches in knowledge management: The Know-net approach.* Paper presented at the Conference Practical Application of Knowledge Management (PAKeM 2000) - April 12-14, 2000, Manchester, UK.

Basque, J., Desjardins, C., Pudelko, B., & Léonard, M. (2008). *Gérer les connaissances stratégiques dans des entreprises manufacturières de la Montérégie: Expérimentation de la co-modélisation des connaissances dans 3 PME*. Rapport de recherche. Montreal: CEFRIO.

Basque, J., Imbeault, C., Pudelko, B., & Léonard, M. (2004). Collaborative knowledge modeling between experts and novices: A strategy to support transfer of expertise in an organization. In A. J. Canas, J. D. Novak & F. M. Gonzalez (Eds.), *Proceedings of the First International Conference on Concept Mapping (CMC 2004), Pamplona, September 14-17, vol. 1* (pp. 75-81). Pamplona: Universidad Publica de Navarra.

Basque, J., & Pudelko, B. (2004). *La modélisation des connaissances à l'aide d'un outil informatisé à des fins de transfert d'expertise: Recension d'écrits*. Montréal: Centre de recherche LICEF, Télé-université.

Basque, J., & Pudelko, B. (2008). *La co-modélisation des connaissances à l'aide d'un outil informatisé. Une stratégie de transfert d'expertise en milieu de travail. Rapport final des expérimentations menées à la Régie des Rentes du Québec*. Montréal: Centre de recherche LICEF, Télé-université.

Basque, J., Rocheleau, J., Winer, L.,Michaud, P., Bergeron, G., Paquette, G., et Paquin, C. (1998) *Un modèle adaptable d'une école informatisée*. École informatisée Clés en main du Québec Inc et Centre de recherche LICEF, Télé-université.

Chi, M. T. H., Feltovitch, P. J., and Glaser, R. (1981). Categorisation and representation of physics problems by experts and novices. *Cognitive Science, 5*, 121-152.

Chi, M. T. H., Glaser, R., and Farr, M. J. (1988). *The Nature of Expertise*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Chi, M. T. H., Glaser, R., and Rees, E. (1982). Expertise in problem solving. In R. Sternberg (Ed.), *Advances in the psychology of human intelligence* (pp. 7-75). Hillsdale, NJ: Lawrence Erlbaum Associates.

Ericsson, K. A., & Charness, N. (1994). Expert Performance: Its Structure and Acquisition. *American Psychologist, 49*(3), 725-747.

Ermine, J.-L., Boughzala, I., & Tounkara, T. (2006). Critical Knowledge Map as a Decision tool for Knowledge Transfer Actions. *The Electronic Journal of Knowledge Management, 4*(2), 128-140.

Glaser, R. (1986). On the Nature of Expertise. In H. Hagendorf (Ed.), *Human Memory and Cognitive Capabilitis: Mechanisms and Performances* (pp. 915-928). North Holland: Elsevier Science.

Imbeault, C. (2007, november). *Projet GIT, Gestion de l'information technique Automatismes de Production*. Rapport d'étape. Hydro-Quebec internal document.

Paquette, G. (2003*). Instructional Engineering in Networked Environments*. Pfeiffer.

Schön, D. A. (1983). *The reflective practitioner: How professionnals think in action*. New York: Basic Books.

Schmidt, H. G. and Boshuizen, H. P. A. (1993). On Acquiring Expertise in Medecine. *Educational Psychology Review, 5*(3) 205-221.

Sternberg, R. (1997). Cognitive Conceptions of Expertise. In R. R. Hoffman (Ed.), *Expertise in Context. Human and Machine* (pp. 149-162). Menlo Park, CA/Cambridge, MA: AAAI Press/MIT Press.

Sternberg, R. (1999). What Do We Know About Tacit Knowledge? Making the Tacit Become Explicit. In J. A. Horvath (Ed.), *Tacit Knowledge in Professional Practice* (pp. 231-236). Mahwah, NJ: Erlbaum.

Sveiby, K.-E. (2001). A Knowledge-based, Theory of the firm to guide strategy formulation. *Journal of Intellectual Capital, 2*(4).