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# Modeling the Delivery Physiology of Distributed Learning Systems

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This article results from a new development of the MISA instructional engineering method and its web-based support system, ADISA. Delivery models are important because they represent the actors, their operations and interactions and the resources the use or produce for other actor when the system will be in operation. Without sufficient planning, distributed learning systems will generally present high levels of technical and organizational noise that are an obstacle to learning. We will present a delivery model technique which aims to solve these problems. We will show that this technique allows us to represent the learning system at a global level, modeling distance learning paradigms such as distributed classrooms, self-Training on the Web, online training, communities of practice, as well as performance support systems. At a lower level, we model functions within the learning system (physiologies of the organism) such as competency management, learning assessment, resource use or collaboration management. Finally, we discuss the role of delivery and function models in the aggregation of resources or learning objects. The approach is proposed as way to go beyond the actual learning objects integration paradigms for which international metadata standards are being actually developed.

*Keywords:* Delivery models, instructional design, use case modeling, distributed learning, learning objects, distance education, web based learning.

## 1. INTRODUCTION: THE DELIVERY CHALLENGE

A delivery model depicts the interactions between the users and the learning system components, hence its physiology, in order to plan (before), to

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facilitate (during) and to describe (after) the processes represented. In instructional engineering, the design of the learning system produces a delivery model representing the actors and their interactions with the resources they use or provide to other actors. These resources will have to be in place when learners start using the learning system[1]. This delivery plan also allows the designers to provide management personnel with the financial, organisational and logistics information required to create and maintain the learning system throughout its useful life.

Along with the learning and teaching strategy selected, delivery modeling and planning is certainly the most determining factor of the success or failure of a learning system using technologies. One could argue that delivery is the most important modeling area for educational technologists because it describes the real time use of the learning system, instead of the initial somewhat theoretical view of that system by a subject matter expert or an instructional designer. The delivery model is the sole provider of a global and synthetic representation of a learning system needed to manage complex and hybrid phenomenon units that involve individuals, objects, information and concepts amalgamated for learning purposes[2].

Generally speaking, much importance is given to the media involved in building the materials of a learning system. However, in many distributed learning systems, few new material is produced. Often, texts, Internet web sites and pedagogical multimedia material well suited for the target competencies exist and are simply integrated or adapted in the instructional scenarios. It is even possible to create a course without any material, as is the case in communities of practice where the learners, seen as experts, are responsible to build the materials in the context of a project, or through emerging collaboration with their peers.

Regardless of the type of delivery model, the selection of resources, not only materials, is always necessary to build a useful distributed learning environment. Even in a virtual classroom, the information processing tools, communication means, services and delivery environment are critical. Some presentations of interesting subjects fail regularly due to the mediocre quality of the presentation tools or the orator's poor presentation or communicative skills. Moreover, when learners are in a remote location, the presenter cannot afford this type of deficiencies and methodological help and techni-

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[1] For a definition of the delivery design process, see (Paquette et al, 1999).

[2] The second author's doctoral dissertation (Rosca 1999) advocates that the education techonologist's activities should be centered around a Delivery Model.

cal support must be provided.

This situation is even more critical in more advanced models of distributed learning, such as hypermedia self-paced learning, online learning, learning communities or electronic performance support systems (EPSS). In these cases, disfunctional resources can amplify difficulties and create a «technological noise» that prevents learning and teaching. This technological noise can be measured by the time spent resolving technical problems, the inability to get help when it is needed, the lost of productivity due to a number of tools that are not compatible, etc. Organisational noise also results from poor coordination between the staff that support training when some people lack knowledge and tools regarding their tasks in a given learning event. Finally, a "comprehension noise phenomena" emerges when the planing facilities do not provide interaction observation facilities on the spot.

This article presents a delivery model technique which aims to solve the aforementioned problems. We can model delivery situations at different levels:

- The delivery type of the system (the organism) : Distributed Classroom, Self-Training on the Web, Online Training, Learning Community of Practice, Performance Support System.
- The functions within the learning system (physiologies of the organism): competency management, learning assessment, material, resource and collaboration management, etc.
- The operations performed by certain actors in the context of one or more of these functions (the organs), relating the operations to the materials and resources used or produced for other actors.

Section 2 of this article introduces delivery modeling and its main tasks. Section 3 presents various types of delivery models (distributed learning organisms). Section 4 deals with the use of delivery models to build various physiologies in a distributed learning system supporting the actors' interaction to performs roles using and producing resources for himself or other actors.

## 2. BUILDING DELIVERY MODELS

In (Paquette 2001) we have presented the general processes and principles of a new instructional design method. MISA lies in the general framework of systems science (Simon 1973; LeMoigne 1995) in which a system is defined as a set of dynamically interacting elements, organized or organizing themselves towards a goal. Here, our goal is to build a learning system and more specifically, a Web-based distributed learning system. MISA is rooted in three fields: instructional design theories (Reigeluth 1983, Merrill 1994, Scandura 1973, Spector 1993, Tennyson 1988), software engineering (Schreiber et al 1993, Boosch et al 1999, Rumbauch et al 1991) and knowledge modeling (McGraw and Habison-Gibbs 1989, Hart 1988, Paquette et Roy, 1990).

MISA[3] is composed of 35 main tasks distributed into 6 phases and 4 orthogonal axis: knowledge and competency design, instructional design, media design and delivery design. MISA integrates a delivery planning process generated by three groups of tasks:

a) Stating the orientation principles of the delivery of the learning system are stated;
b) Creating one or more delivery models that emphasize the relationships between the actors and the resources: material, tools, means of communication, delivery services and locations;
c) Defining a quality control mechanism to be implemented at the creation of the learning system and subsequently upgraded while the system is used, including a learning assessment process and periodical reviews of the content, the materials and the learning environments.

### 2.1 The Delivery Specifications of MISA

Creating and documenting one or many delivery models are the most critical delivery planning tasks. Figure 1 presents an example of a model created by one of the co-authors and currently used in an artificial intelligence course broadcasted by *Télé-université du Québec*.

This model highlights the interaction between six types of actors: learners, instructors (also called tutors), designers, managers, network administrator, and shipping clerks. These actors perform various operations: using the distributed learning system (DLS) that includes Web content and printed material, ensuring pedagogical support, creating and maintaining the Explor@ web site and the networks, and publishing and updating the course web site mailing material.

This model presents many types of resources:

[3] The development of MISA started in 1992; see (Paquette et al, 1994) for an early presentation.

[4] For a description of the Explor@ delivery system, see (Paquette et al 2001)

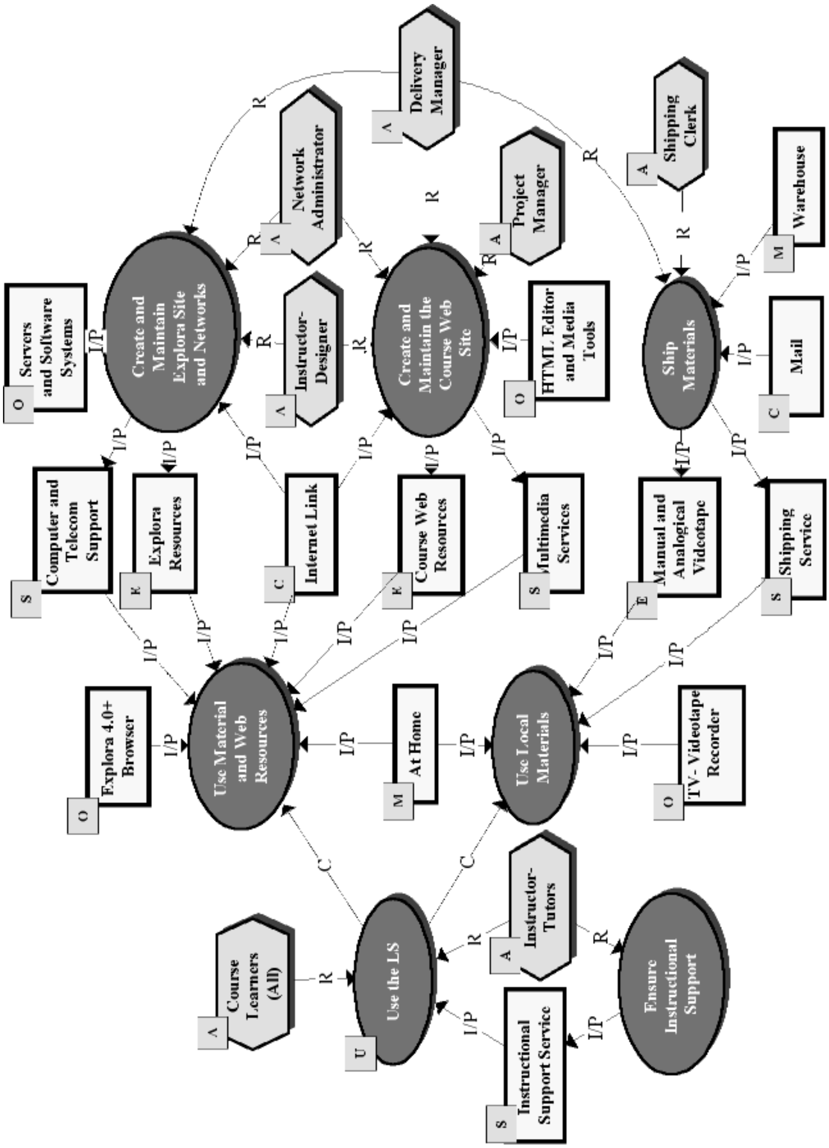


FIGURE 1
An example of delivery model

a) three types of material: the course web site, the Explor@[4] web site that manages the actors' environment and the non-computerized resources (books, videotapes);
b) two means of communication: the Internet and the regular mail.
c) many tools: software packages, web browser, TV station and VCR to view videotapes at home, an HTML editor and other media authoring tools to update the web site, as well as servers and software to create and maintain the Explor@ environment and the network components.
d) services offered to the participants, as well as the locations where activity takes place: the participants' home where all learning activities are undertaken and a warehouse from where the course material is shipped.

This example concertizes the concept of Delivery Models. It is a process graph[5] that reveal the interactions between various actors. The main components are (a) the actors, presented as principles (hexagonal boxes); (b) the operations, shown as procedures (oval boxes) or (c) the resources, material, tools, services, environment and communication means displayed as concepts (rectangular boxes). Delivery rules which indicate ways to perform the operations can also be included.

## 2.2 Construction of a Delivery Model

The construction of a Delivery Model can undergo six main steps.

<u>Step 1</u>: First, we must decide if a single or many Delivery Models are required. Then, we specify the purpose of the model(s). There can be various ways to deliver the LS, many types of global physiology, as stated in the delivery orientation principles: totally distance learning delivery, self-learning delivery, class-web site hybrid delivery, and so on. Second, if we wish to build an environment for each actor, it would be worthwhile to create a model that is centered on the actor's operations, productions and the required resources that will be included in his/her environment. Finally, some delivery procedures, such as tests might need their own delivery models that can be re-used for maintaining the learning system.

<u>Step II</u>: Once the purpose of the model is established, each actor and his/her main operations and corresponding R-links are included in the graph. For example, are there many types of learners present in a class or in a remote location? Are they equipped with efficient means of communication?

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[5] The figures of this article were produced with the graphic editor MOT (Paquette 1996,1999). The rectangles display resources, the oval shapes represent the operations and the actors are associated to hexagons. The links that connect these components are the following: C (is a component of), S (is a sort of), I/P (is an input or a product of ), R (regulates).

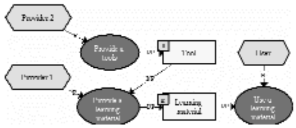

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FIGURE 2
Interactions between users and resource providers

We also create one or many operations for each type of learners or for other categories of actors and we identify the material and resources necessary for each operation.

Step III: Then, for each of these operations, we identify and link the required material and resources and we relate them using I/P links to each operation already on the graph.

Step IV: For each resource already on the graph, we identify which actor can provide that resource and we represent this provider on the graph by an hexagon, link to an operation by a an R-link, and we link that operation to the resource it produces.

Step V: We then determine the resources these primary providers need as user and add to the graph the secondary providers who render these resources to them. In Figure 2, Provider 1 uses a tool provided by Provider 2 to supply the material to the user.

Step VI: If necessary, we add to the model other elements that specify various aspects of the delivery such as the delivery packages grouping materials and delivery rules specifying conditions to performs some operations.

A main delivery model such as the one displayed in Figure 1, can comprise sub-models. We can create sub-models using a selection filter to display the resources used or produced by a single actor, or to display the multi-actor activities around a subset of the operations involved in the model.

## 3. TYPES OF DELIVERY MODELS

Table 1 introduces the components of five categories of delivery models. Following that table, a schematic delivery model is displayed for each category. Such a basic collection of delivery models can be used as a starting point, and adapted to the needs, objectives, contexts and constraints of a new

TABLE 1
Categories of delivery models

| Main Components | Types of Delivery Models | | | | |
|---|---|---|---|---|---|
| | Distributed Classroom | Self-Training on the Web | Online Training | Communities of practice | Performance Support System |
| Learners' Actions | Receive input, ask questions, complete exercises | Autonomous Learning, accesses information | Asks questions, cooperation, telediscussions | Cooperation, telediscussions, information exchange | Exercises, case studies, simulations |
| Facilitators | Presenter | Training manager | Trainer, presenter | Group animator | Support manager |
| Main type of Material | Presentations, videos, information websites | Internet and multimedia training | Productions, informative websites | Productions, informative websites | Activity guide, contextualised help files |
| Model-Specific Tools | Video-conferencing system, browser, presentation tools | Browser, search engine, multimedia support | Forum, e-mail, multimedia documents | Forum, e-mail, multimedia documents | Computer systems and organizations' data bases |
| Means of Communication | Synchronous telecom | Asynchronous telecom | Asynchronous telecom | Asynchronous telecom | Asynchronous telecom |
| Required Services | Technical support | Communication support | Communication support | Communication support | Systems technical support |
| Delivery Locations | Classroom, multimedia room | Residence, workplace | Residence, workplace | Residence, workplace | Workplace |

learning system. This concept of a library of delivery models can provide adaptable and combinable functionalities to construct an expertise for the engineering, use and analysis of distributed learning systems.

### 3.1 Distributed Classrooms

Figure 3 presents a distributed classroom model. In this model, five groups of learners occupy five distinct classrooms and the instructor is situated in a sixth room. A technician who ensures the right working order of the equipment and provides a user's guide for this equipment assists the instructor.

The professor here is mainly a content presenter using sophisticated presentation tools. He also answer questions, provides learning materials and give coaching services. Both the instructor and the learners use a videoconference system. Between two presentations, the professor assist learners and assess their work using the Internet.

The learners' roles consist in attending lectures and asking questions to the instructor using the videoconference system located in the multimedia room closest to their homes. Between two presentations, they use the

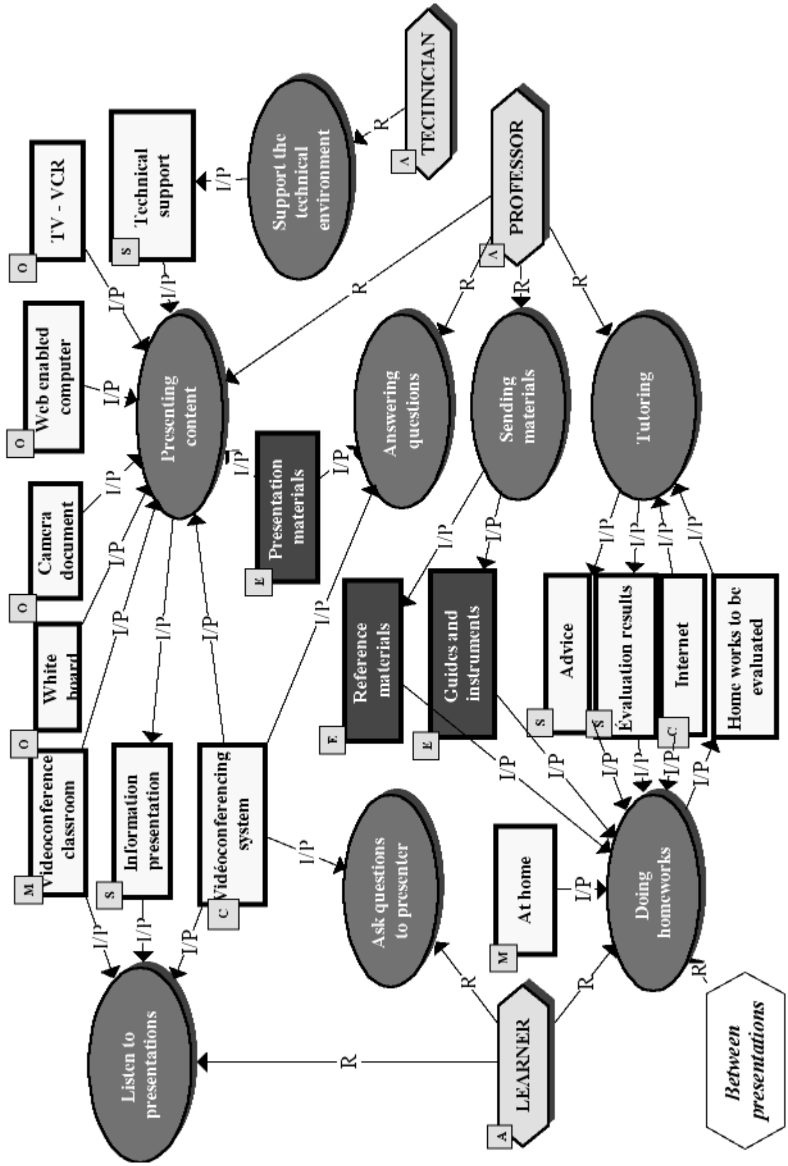


FIGURE 3
A delivery model for a distributed classroom

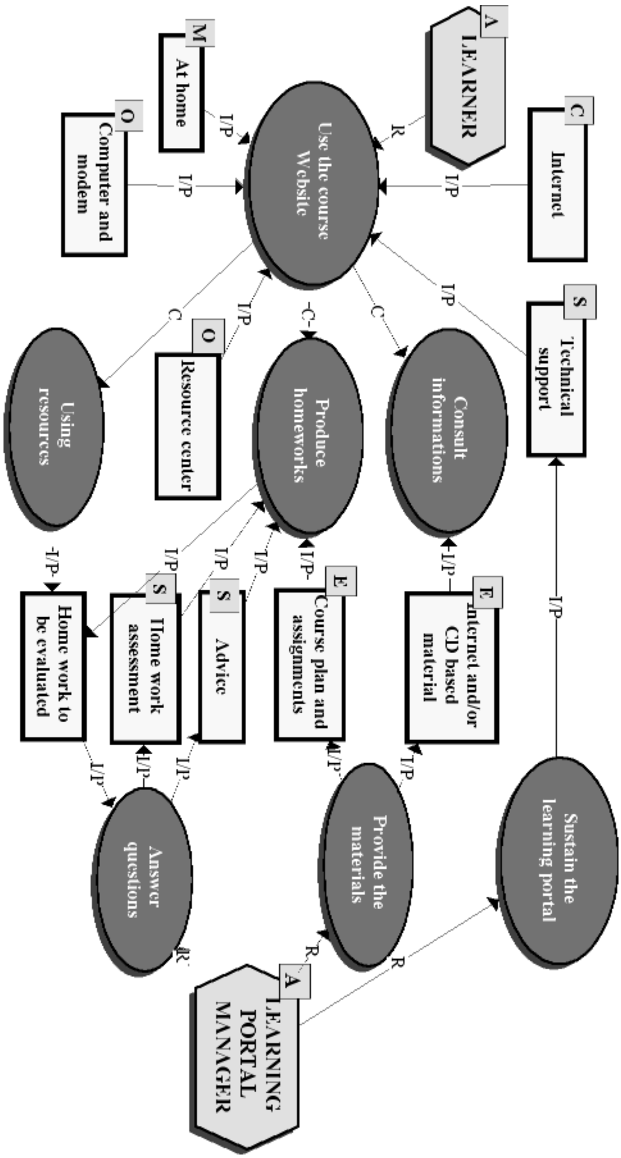


FIGURE 4
A delivery model based on the hypermedia distribution concept

Internet to consult reference material and documents provided by the instructor. They also use this medium to forward their homework to their instructor.

### 3.2 Self-Training on the Web

In Figure 4 model, a learner has registered to access a hypermedia course on the web. This autonomous learning takes place either at home or in another location selected by the learner. Learners use computers and multimedia peripherals. They have access to a learning portal that provide them with documents software tools, means of communication, help, advice, and homework assessment. Their roles are threefold: to use the web site resources, to complete the homework and to consult information on the Internet, downloaded onto their workstation or distributed on a CD or DVD-ROM.

The learning portal manager who administers the site can also be a trainer who offers technical support and advice. In some cases, this actor can also assess the learners' work as well, create and maintain a web site user's guide as well as a syllabus and digitized information related to the course.

### 3.3 On line Training

Figure 5 shows an asynchronous on-line learning model where learners follow an online course (Harasim 1990, Hiltz 1990) presented by an professor located in his own home or office. Multimedia and network technicians provide the technical resources to both primary actors.

The on-line professor's role is to design, produce and present the learning material on the web site and also provide pedagogical support and animation of the telediscussions or forums using asynchronous tools (such as forum, e-mail, file transfer) that are also available to the learners. The learners, in an asynchronous resource centre, access the assignments of the course, the presentation materials and the communication and collaboration tools that allow them to produce teamwork and participate in telediscussions. Their work is published on a student work showcase or forwarded to the instructor for evaluation and feedback.

### 3.4 Learning Communities of Practice

Figure 6 model presents a group of participants engaged in an Internet based learning community of practice (Ricciardi-Rigault et al, 1994, Wenger 1998), at their home or their workplace The members of the group produce and present information related to a specific task or they solve a specific

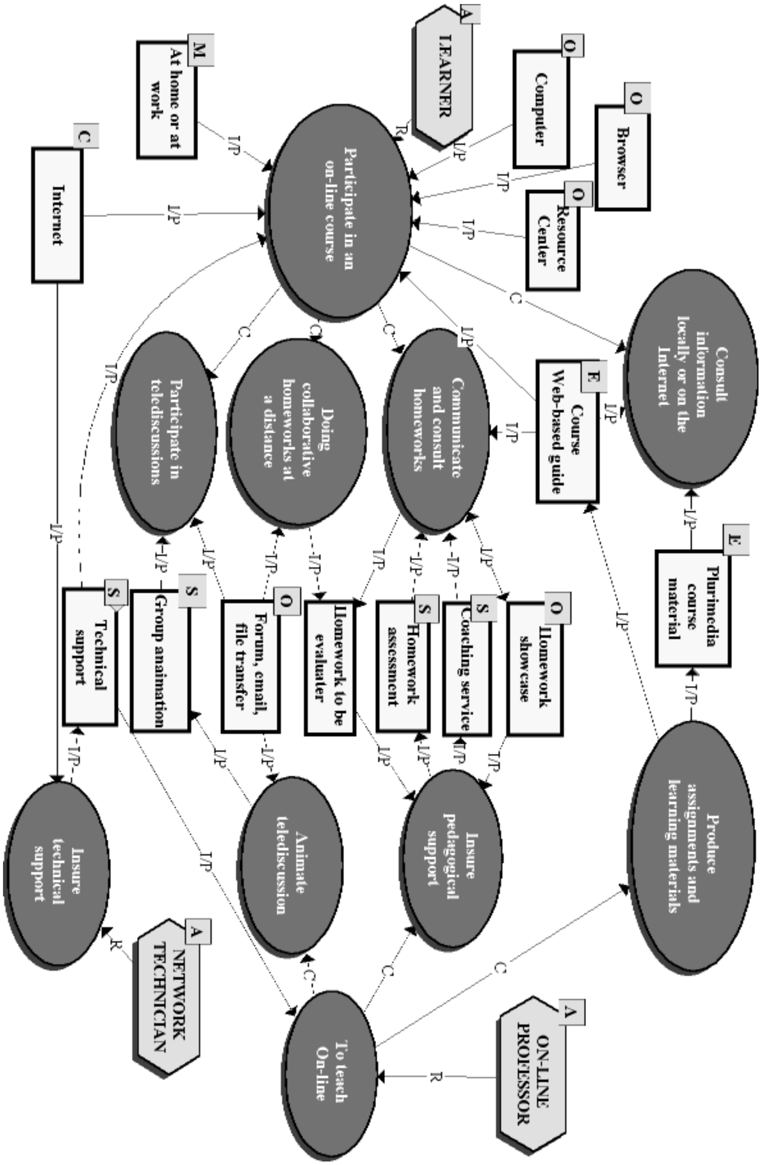


FIGURE 5
An Online learning delivery model

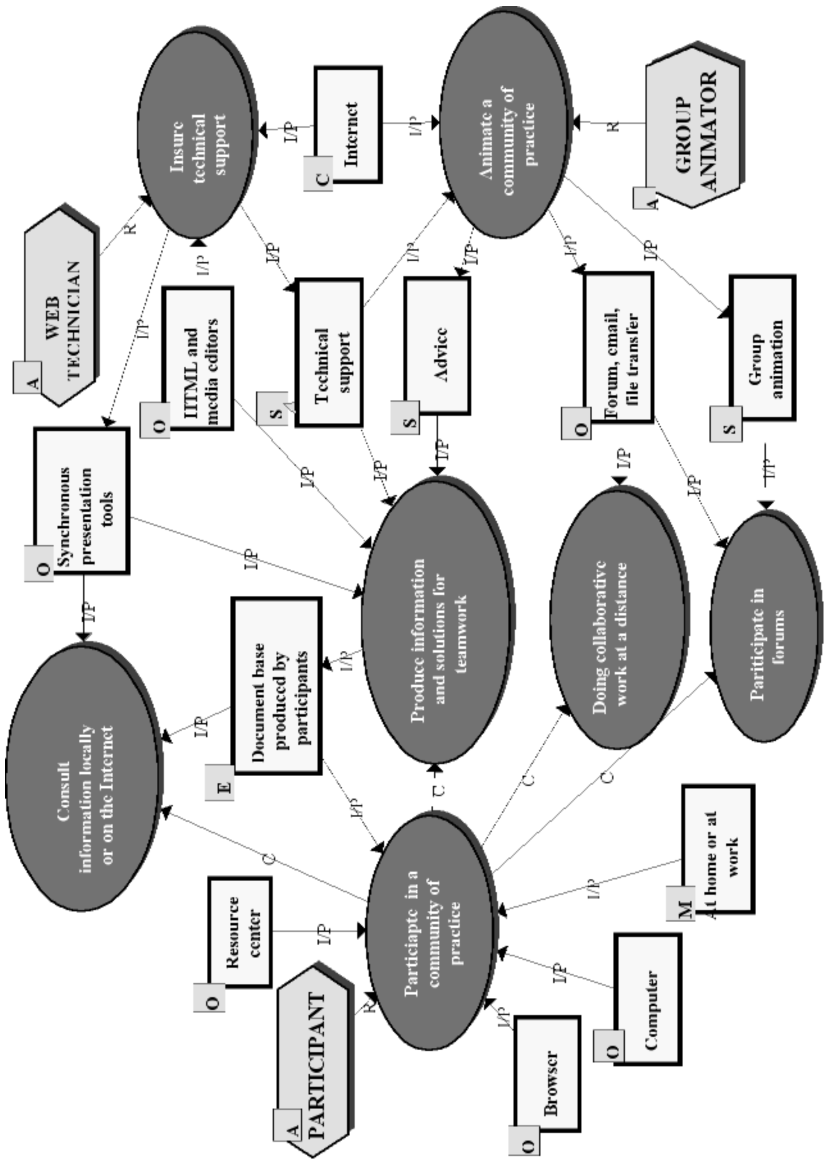


FIGURE 6
A Learning Community of Practice Model.

problem. They use asynchronous forums and/or synchronous tools.

This model allows the participants to share knowledge and expertise to build a collection of re-usable documents. Work is completed individually or results from team collaboration. The telediscussions serve as a forum to interchange professional praxis. The work is driven by the analysis, assessment and pooling of the members' contributions. An animator in a remote location leads and assists the group helping in the orientation of the work. A web technician provides technical support and helps to build and maintain the collection of documents.

### 3.5 Electronic Performance Support Systems

The learners of Figure 7 model are work colleagues using an electronic performance support system (EPSS) (Gery 1997) offering integrated training and work activities. They are equipped with the same databases, documents, and tools as those used at work. These organizational resources are provided and supported by the workplace technicians. The learners acquire knowledge and competencies by solving problems similar to those experienced in the workplace. Learners use hyperguides that provide activity assignments to be completed with the training material published on the Internet. The learning material is created and maintained by the training organization designers. The target competencies are validated though various exercises and tests.

A trainer-manager supervises the learners' work and training by providing advice and assessing their work and acquired progress in knowledge, skills and competency.

## 4. FROM PHYSIOLOGIES TO ACTORS' ENVIRONMENTS

We will now take these concepts a step further and describe how various delivery models can create environments that provide the necessary resources to the actors involved in performing the main functions of a distributed learning system. This procedure is composed of three main phases: models that represent the functions of a learning system, models that represent the actors' operations and resources within a function, and finally, the creation of the corresponding actors' environments integrating learning materials, tools and other resources.

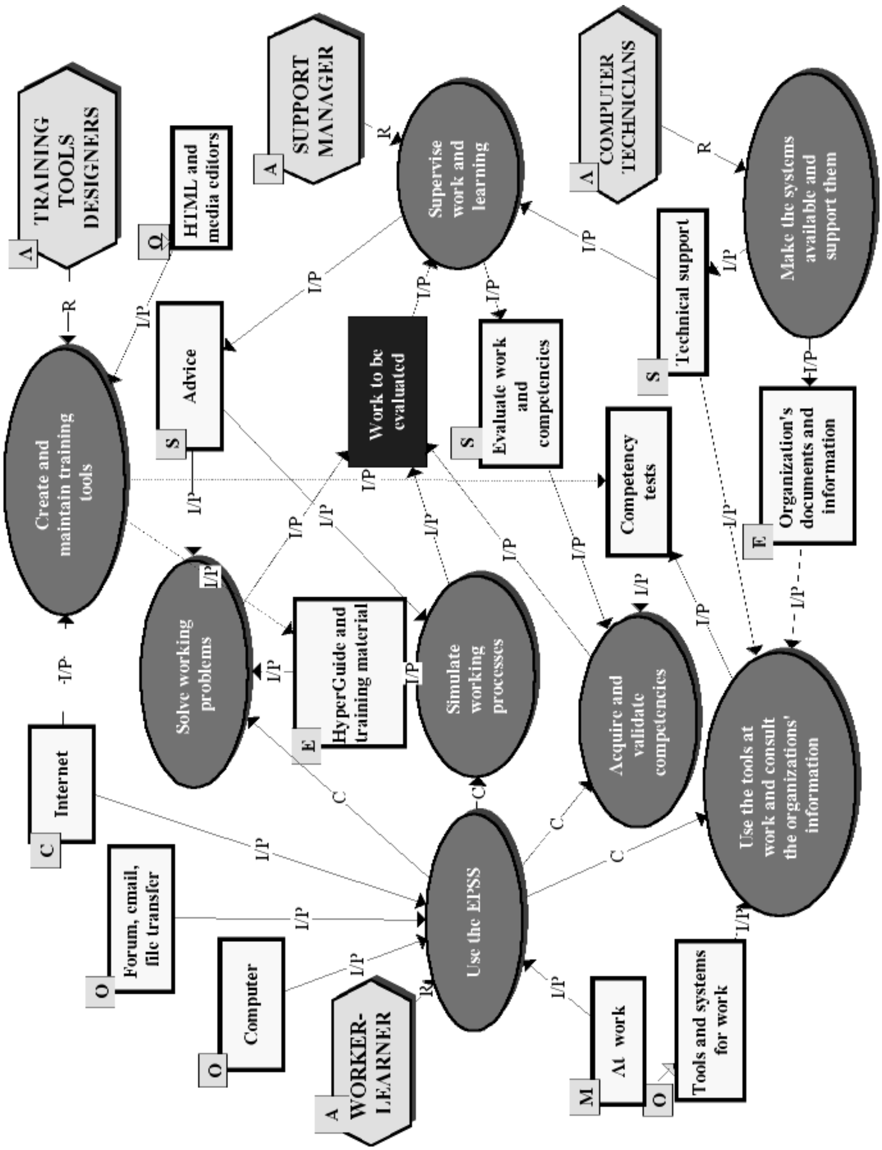


FIGURE 7
A Performance Support System Delivery Model

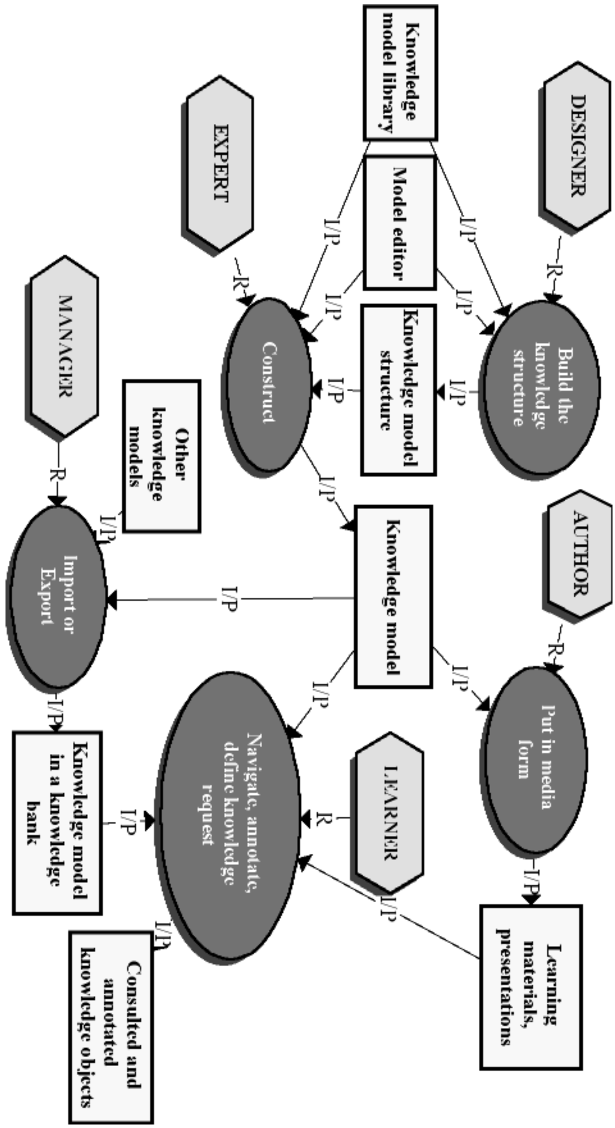


FIGURE 8
A Knowledge Management delivery model

### 4.1 Functions or Use Cases as Delivery Models

Section 3 presented various types of delivery models. A *function within a learning system* is a type of delivery model that corresponds, from a computer science view, to a use case of that system[6]. From a conceptual point of view, in a biological or ecological sense, a function is a particular physiology, an interesting subsystem of operations within of the learning system organism.

We now present eight common use cases with some corresponding function models.

KNOWLEDGE MANAGEMENT

- A designer and a subject matter expert ( SME) develops the structure of a Knowledge Model with a model editor and a knowledge model collection.
- A SME uses these structure and tools to build a model.
- An author uses the model as a reference to prepare presentations and materials, to produce dialogues or annotations, to reference the assessment process, to define the target competencies of the LS, etc.
- Learners interact with the knowledge model to explore the presentations and the pedagogical material, annotate and bookmark material, identify their learning needs, etc.
- A manager exports or imports part of the Knowledge Model to update the knowledge management system or to inform associate organizations.

COMPETENCY MANAGEMENT

- An instructional engineer develops typical competency profiles highlighting the target competencies of learning systems. He publishes or manages the list of the people registered in the courses.
- Learners specify their competencies, their objectives and learning needs. They can indicate or confirm their own competency profiles. They use assessment tools to determine their level of competencies and update their profiles during the course. This data can be stored in the competency management system.
- A SME or a trainer declare his /her competencies and his/her availability (what he/she knows and can/wants to explain and how). To ensure

6 For an introduction to this concept, see (Booch, Jacobson et Rumbauch, 1999), pp.219-243. Use case diagrams are UML (Unified Modeling Language) components.

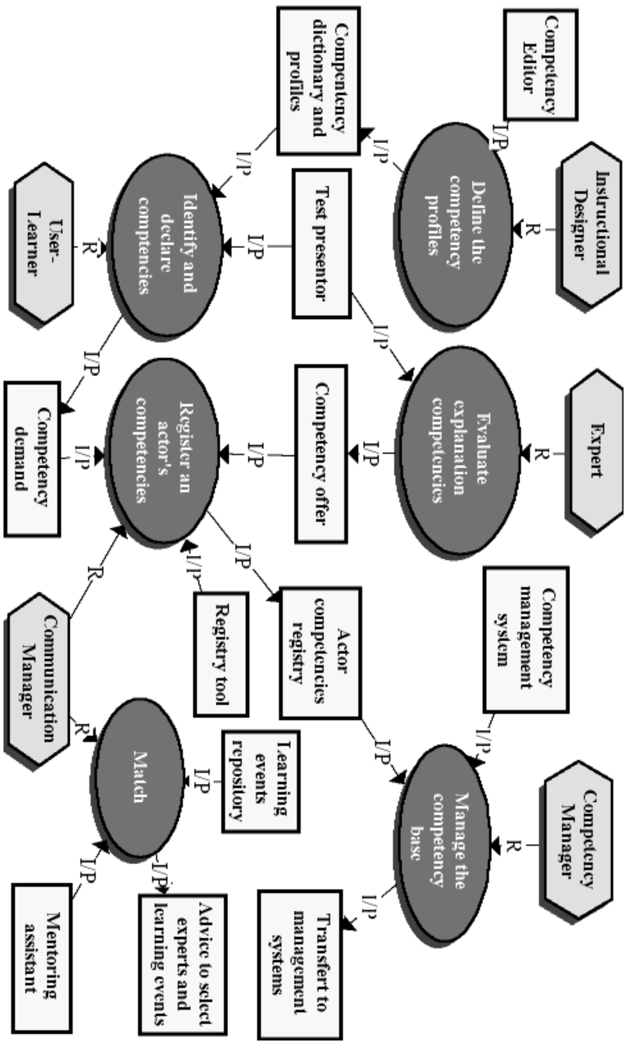


FIGURE 9
A Competency Management Function Delivery Model

an adjacent match, he/she uses the same competence assessment system as potential learners.

- A communication manager guides the discussions between the learners and the experts to favour competency acquisition (knowledge and skills). He/She uses a data bank and a mentoring assistant to suggest learning events and available mentors.

- A competency manager analyses the situation and the evolution of the competency function, produces reports and recommendations, modifies the structure of the competencies, exports the competency data to other systems in the institution or imports competency-related information.

PRESENTATION MATERIAL MANAGEMENT

- A designer develops presentation materials and define their structure, relates them to knowledge and describe them using metadata. He/She creates and manages access policies, search engines, Q & A mechanisms, etc.
- A learner requests presentation material related to a specific issue for himself/herself or for the entire group. This request is forwarded to an animator.
- A trainer informs an animator that presentation materials related to a specific issue is required for a specific (group of) learner(s). He/She can also offer suggestions for this material, organize registration procedures and coordinate group activities.
- An animator prepares a presentation: he/she creates or finds pertinent material, documents its availability, negotiates the time/date of the presentations. He/She presents explanations (text, video, tutorial, web site, etc.) and answers learners and trainers questions. When a greater audience can benefit from his/her response, the presentation is published on a web site or delivered live to an audience.
- Learners search for materials or presentations to improve their competencies or SMEs knowledge. They use various tools to search, view, read, and annotate the presentations.
- A trainer searches a presentation for a learner or uses support material in his/her own presentation. He/She documents the impact of the presentation by annotating a document that describes the presentation.
- A manager studies the uses and commentaries of the presentations. He/She exports and imports the presentations and the bookmarks in a bank of materials.

DIALOGUES AND COLLABORATION MANAGEMENT

- A designer develops a collaboration space containing communication tools and protocols, correlated with knowledge; he defines management assessment files describing tasks involving access policies for synchronous and asynchronous dialogues.

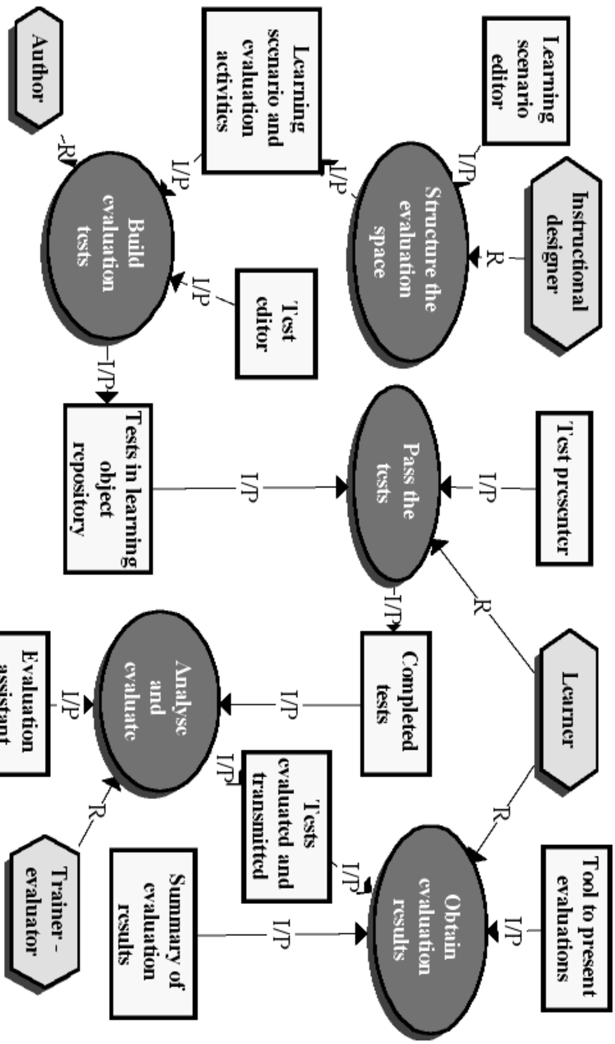


FIGURE 10
A Learning Assessment Delivery model

- A learner indicates a communication need or a collaborative learning event. Learners can offer others their own collaboration as well. A peer collaboration system supports the learners.
- A trainer prepares a collaborative activity, builds or directs learners towards documents required to complete activities. Trainers announce

their availability for synchronous meetings or forum participation and negotiate time/date. Trainers offer conferences.
- Learners register for collaborative activities. They participate, meet other colleagues and manage their cooperation.

LEARNERS EVALUATION
- Designers structure the evaluation area. They use a instructional engineering tools to define scenarios, activities and evaluation instruments.
- Authors create tests. The tests are referenced with the other learning objects for other actors' access.
- A learner finds an appropriate test, completes it and forwards it to a trainer for assessment.
- Once corrected, the trainer documents the evaluation results.
- Once trainers have corrected the tests, compiled the marks and annotated their corrections, the tests are placed in an assessment bank and available to the learner and the training manager.
- The learner obtains evaluation results and acts using this information.

RESOURCES AND MATERIAL MANAGEMENT
- A pedagogical engineer organizes the available resources for the learning events.
- A designer describes each resource and its metadata, such as the copyrights and access restrictions.
- A learner, a trainer or a designer requests, obtains and uses a resource and provide comments or quality assessment
- A manager documents the usage of the resources. He/She ensures the documents are used adequately and remain available. If revision is needed, requests are forwarded to instructional engineers.

EMERGING ACTIVITIES MANAGEMENT
- A pedagogical engineer defines the protocols of emerging structures to specify the objectives, the actors and the resources. He/She specifies the tools and means of communication, adaptation and production of new resources, cooperation management, defines problems or projects and builds a group knowledge database.
- A learner participates in an open and flexible learning process that favours the emergence and dynamic evolution of learning activities.
- A trainer organizes teleconferences or suggests new resources to feed expertise and knowledgeable discussions.

TABLE 2
Actors in interaction with three functions of the Learning System

| Functions | Actors Name | Selected Actor's Name | Materials and Resources Used | Materials and Resources Produced |
|---|---|---|---|---|
| **Knowledge Management** | Expert | EXPERT | (T) Model Editor<br>(M) Model Library | (M) Knowledge Model Structure |
| | Designer | EXPERT | (T) Model Editor<br>(M) Model Library<br>(M) Model Structure | (M) Knowledge Model |
| | Author | EXPERT | (M) KM Structure | (M) Presentations, Materials, etc. |
| | Learner | LEARNER | (M) Knowledge Models<br>(M) Models integrated in a Knowledge Bank | (M) KM checked, annotated, learning needs |
| | Manager | EXPERT | (M) Other Knowledge Models | (M) models integrated in a Knowledge Bank |
| **Competency Management** | Instructional designer | DESIGNER | (T) Competencies Editor | (M) Competency dictionary, and profiles |
| | User-learner | LEARNER | (T) Test Presenter<br>(M) Competency dictionary, and profiles | (M) Competencies demand |
| | Expert | EXPERT | (T) Tests presenter | (M) Competencies offer |
| | Communication Manager | TRAINER | (T) Mentoring assistant, Registry Tools<br>(M) Learning events repository | (M) Competency DB<br>(M) Advice to select experts and learning events |
| | Competency Manager | TRAINER | (T) Management and Exportation Tools<br>(M) Actors competency registry | (M) Transfer to management systems |
| **Learners evaluation** | Instructional designer | DESIGNER | (T) Learning Scenario Editor | (M) Scenarios and Evaluation Activities |
| | Author | EXPERT | (T) Test Editor<br>(M) Scenarios and Evaluation Activities | (M) Test in learning object repository |
| | Learner | LEARNER | (T) Test Presenter<br>(M) Test in learning object repository<br>(M) Summary of evaluatin results | (M) Completed Test |
| | Trainer-evaluator | TRAINER | (T) Evaluation Assistant<br>(M) Completed Test | (M) Evaluated and transmitted tests |

(T) : Tools ; (M) Materials

- A manager observes and analyses in synchronous or asynchronous mode the learning process. He/She may request the intervention of a trainer or a designer.

## 4.2 The Actors' Role – Interaction Areas

Functions provide an inventory of the resources used or produced by an actor. Table 2 summarizes the three functions presented in Figures 8, 9, and 10. Column 2 presents the actors in these models, while column 4 and 5 displays the resources they use or produce in the model for the operations each actor regulates.

TABLE 3
Resources by actor and by selected function

| Selected Actor's Name | Function | Material and Resources Used | Material and Resources Produced |
|---|---|---|---|
| LEARNER | Learners evaluation | (T) Test presenter<br>(M) Test in learning objects repository<br>(M) Evaluation results | (M) Completed test |
| | Competency Management | (T) Test presenter<br>(M) Competency dictionary and profile | (M) Request of Competency |
| | Knowledge Management | (M) Knowledge model<br>(M) Model integrated in a knowledge base | (M) Models processes |
| DESIGNER | Learners evaluation | (T) Scenario Editor | (M) Scenarios and evaluation activities |
| | Competency Management | (T) Competencies Editor | (M) Competency dictionary and profile |
| EXPERT | Learners evaluation | (T) Test Editor<br>(M) Scenarios and evaluation activities | (M) Tests in a learning objects repository |
| | Competency Management | (T) Test presenter | (M) Competency Offer |
| | Knowledge Management | (T) Model Editor<br>(M) Model Library<br>(M) Model structure<br>(M) Knowledge base | (M) Model structure<br>(M) Knowledge Model<br>(M) Presentations, Materials, etc<br>(M) Model integrated in knowledge base |
| TRAINER | Learners evaluation | (T) Evaluation Assistant<br>(M) Completed test | (M) Evaluated Test |
| | Competency Management | (M) Collaboration Assistant<br>(T) Registering Tools<br>(M) Learning events repository<br>(T) Management and Exportation Tools<br>(M) Competency registry | (M) Competency registry<br>(M) Advice on learning events and experts<br>(M) Transfers to Competencies registry |

Table 2 shows that actors might bear different names in different functions. Column 3 forces the unification of actors that bear different names for different functions. They are chosen generally to adapt to types of actors specific to an organization. For example, the actors identified as teachers and managers (1st model), experts (2nd model) and author (3rd model) were standardized under the term EXPERT. These names will be used to designate the actors in the delivery environment grouping resources for these actors.

Removing the second columns Table 2 and sorting this table for these standardized actor names produces Table 3. This table indicates, for each function in the system, the resources used for each actor or produced by them.

Indirectly, these resources specify the actors' operations or roles. As displayed on Table 3, in the function "Learning Assessment," the expert must produce assessment activities. He/She also uses a test editor to generate tests, which are stored in a learning object repository. In the "Competency

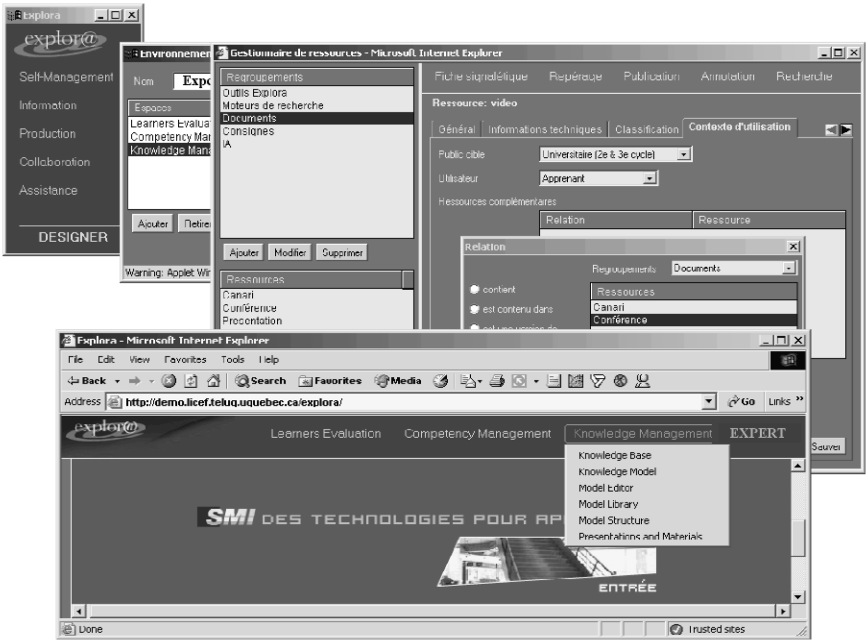


FIGURE 11
Creation of the actor's environment

Management" function, the expert takes a test to assess his/her competency offer. In the "Knowledge Management" function, models must be defined, built and integrated in a model library; they are also used to generate oral presentations or learning material.

### 4.3 Creating the Actor's Environments

Table 3 defines the resources used or produced in each function for the creation of an environment for each actor. For this we use an open delivery system like Explor@. (Paquette 2001, Lundgren-Cayrol et al, 2002). Figure 11 presents the results of such an environment for one of the actors, an expert acting in a course called "Des technologies pour apprendre".

The upper part of Figure 11 shows a designer using an Explor@ tool to define three groups of resources corresponding to the three functions of table 3. The designer can add new resources to the learning object repository if necessary using a resource manager metadata enabled. Then, he/she specifies the interactive spaces associated to each function and the corresponding resources that the expert needs to perform his/her operations in each of the functions..

The lower part of Figure 11 displays the Expert's environment. This window adds to the course web site three menus that offer the resources identified for this actor in Table 3. On the figure, we see the knowledge management set of resources. Other environments can be created from Table 3 for the other actors in the system

## CONCLUSION

This article has presented delivery models enabling the design of actor-centered environments to support the actor's operations within each function modeled when the system was designed.

The instructional operation system Explor@ allows this type of approach because of its flexibility. In a recent review (Harmbrech 2001), we have noticed that the distance learning support platforms currently available are designed for predefined actors. Usually, these platforms provide a fixed set of tools and resources for an author, a learner, and sometimes, a trainer.

The open and versatile framework presented here allows for any set of actors without predefining the functions. It allows the investigation of interactions between actors whose resources are dynamically related to the operations they perform in the system. Hence, delivery models and their functions combined to form very different distributed learning systems such as electronic performance support systems (EPSS) integrated in a workplace activity or, at the other end of the continuum, formal distributed classroom activities.

We are currently upgrading the Explor@ system so that the graphic delivery models act as user interfaces at delivery time, a more general and dynamic alternative to hierarchical menus or structures that will facilitate the actors interactions and coordination. This new version will display a graphic interface for each function of the learning system. It will inform the actors about the context of the operations they perform in different functions, give access to the latest version of the resources produced by other actors, provide access to update the resources they provide to others. In addition, communication, metadata referencing, group annotation and assistance facilities will be accessible from the graphic object representing any operation.

We believe this solution will resolve many of the coordination difficulties encountered in all distributed learning systems. Especially in contexts where the actors and resources change regularly, the learners will benefit from constantly knowing where a specific resource or information can be found and which actors they can communicate with on that respect.

The actors' environments based on delivery models aggregate resources, which can be referenced using metadata standards. The models include assembly rules to build larger more meaningful resources by representing functions of the learning system. They aggregate actors, resources, functions, and environments dynamically. The results are new resources described not only by their component parts, their anatomy, but also by their dynamic aspects, their physiology.

Our future work will analyze the impacts of this framework on the metadata referencing standards such as IMS. (Wiley 2002) mentions that the main challenge for the interoperability of learning objects is in the instructional design than platforms interoperability that have motivated their initial development. We also believe that instructional engineering is key to offer solutions to the aggregation and interoperability of learning objects.

We hope that the ideas presented in this article will contribute to the solution of this aggregation of learning objects, and more generally, to efficient and significant solutions to build more meaningful and useful distributed learning systems.

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