A Principled Approach for the Construction and Reuse of Learning Designs and Learning Objects

Gilbert Paquette, Olga Marino, Karin Lundgren-Cayrol, Michel Léonard

CICE Research Chair, LICEF Research Center, Télé-université, Montreal

gilbert.paquette@licef.teluq.uqam.ca

Abstract

This chapter summarizes the work on instructional engineering and educational modeling accomplished since 1992 at the LICEF Research Center of Télé-université by the researchers of the CICE Research Chair. Recent results on learning design modeling and learning objects reusability processes are thoroughly presented using examples drawn from many projects conducted in the last three years. These are discussed to uncover the importance of a principled approach for the modeling of learning design and the reuse of learning objects in Technology Enhanced Learning environments. Finally, delivery and dissemination issues are discussed and a summary of on-going research is presented.

Introduction

At the end of the 90s, technology enhanced distance learning developments were driven by dreams of producing high quality, low cost, online courses for massive delivery, based on the available e-learning platforms. Most of those platforms offer three types of loosely connected services: communication services such as discussion forums, chats and email; basic information delivery services to present course resources such as documents, syllabus and management services to help professors keep track of student's participation and products.

In the beginning of the 2000s, it was evident that low cost courses were more difficult to realize than expected unless they reproduced low quality classroom processes. Indeed, developing high quality distance learning courses or course modules remains a complex task. Both in the design, the development and the delivery phases, different actors and disciplines are involved: instructional designers, media, ergonomic and graphical experts, experts in information and communication technologies and cognitive scientists as well as learners, tutors, professors and support staff. Moreover building, maintaining and supporting a rich, learner centered distance learning environment is a difficult and expensive task.

Does all this mean that it is impossible to produce high quality economically viable e-learning? The good news is that advances in research are starting to be transferred into practice implementing new ways to attain this dream. The key requirements for these advances can be grouped into four complementary dimensions: quality, viability, dissemination and reuse.

- Regarding quality issues, we need to center the efforts on pedagogy, sound methodologies, innovative course design processes, instrumentation and support, offering powerful and user-friendly technological tools that support the design, the development and the delivery of rich and flexible e-learning situations.

- Regarding viability issues, we need to generalize norms and standards to allow the interoperability the various learning environment components such as the pedagogical method or learning design objects, the learning materials or content objects and the tools or processing objects. Consolidating repositories of best practices, templates and course components will allow for faster, and possibly better, course development by re-composition or specialization.

- Regarding dissemination issues, we need to transfer to actual practice the approaches from the preceding dimensions to the different actors through various strategies such as training and best practice examples, supporting the emergence of communities of research and practice and their networking, defining clear open intellectual rights management, sharing and recognition rules.

- Regarding reusability issues, we need to provide quality assurance strategies including both technical and pedagogical high quality criteria. These criteria can be implemented during conception, and applied as evaluation instruments after reuse to establish a feedback loop, that will assure quality.

Although conceptually independent, those dimensions are tightly related, standards such as the educational modeling language IMS-LD for learning designs or the LOM for learning objects description, because they are guided by instructional design principles. Once accepted, they establish a favorable context for instructional design processes and tools. An important challenge is to provide principles, methods, processes and tools that are both adapted to current standards and norms and broad enough to help those same standards to evolve, to integrate new dimensions and possibilities.

This philosophy has inspired our team working on technology-enhanced distance learning for the past ten years. In this chapter we will present some of the advances in this field, illustrating them with examples from our own experience and work. The chapter will address the different issues while going from the theoretical and methodological dimensions of instructional engineering principles and strategies through the practical and technical dimensions of methods, processes, tools and information systems' support.

Placing our methodological approach at the crossroad of instructional design, software engineering and knowledge management, section 1 will state the main pedagogical processes and principles that we are proposing and that provide the conceptual background for our MISA methodology for learning system engineering.

Using this theoretical and methodological framework, section 2 will focus on educational modeling languages and the IMS-LD standard specification. The role of such a language in the design and development process as well as its relation to design and delivery methods and tools will be presented.

In section 3, we will illustrate the design and development of a distance learning environment by discussing the integration of learning objects to learning designs through a concrete use case, addressing the concerns of reusability influencing both learning

resources and learning scenarios (both are seen as types of learning objects), through the use of the MOT+LD graphic modeling software.

Section 4 will address the delivery, implementation and dissemination dimensions. Community building, repository integration and interoperability as well as transfer strategies such as training and construction of best practice cases will be discussed. The Canadian portal of learning designs, IDLD[1], will be used as a case study for this section.

The chapter will conclude with the identification of some research trends such as knowledge and competency representations, working and learning process alignment, quality assurance and learning design personalization as one of the emerging issues affecting the reuse of learning objects.

1. Instructional Engineering: Principles at the Center

At the beginning of the new millenium, new technological and socio-economic environments challenge the instructional system models and theories developed in the sixties and the seventies (Reigeluth 1983), before the Internet era. This is not to say that these models and theories have become obsolete just because people have started to learn using new and rapidly evolving technology, but that they evolve incorporating new technology. Genetic evolution is a very long process and the human brain still functions in much the same way as it did forty years ago.

In fact, these theories and models still provide a solid foundation for instructional design. The problem lies mainly at the level of operational and methodological inefficiencies, as many researchers in the field have pointed out since the beginning of the nineties. Gerry (1997) states: "traditional ID practices being too slow and costly for many situations, electronic performance support systems (EPSS) must be developed". Gustafson (1993) comments: "While there have been moderate additions to the tool set and some changing of perspective from a behaviorist to a cognitive psychological orientation, to date they do not represent a fundamental change in the tool set". In the same article, he adds: "ID methodology is just incomplete and inadequate for facing many of the challenges of the next decade and the coming millennium".

These rather hard criticisms are still valid today. They are supported by the large set of interrelated decisions to make when building technology-based or on-line learning environment. These are decisions such as the following: What kind of delivery model shall we use or what mixture of these models? Will we support learners and trainers anywhere, anytime, at any pace; are there exceptions to this? What kind of learning scenarios do we need for this course? Should it be predefined, offer multiple learning paths or be learner-constructed? Which actors will interact at delivery time, what are their roles, what resources do they need? What kind of interactivity or collaboration should be included? Will we use multimedia or plurimedia materials? What materials can be reused and which ones need to be modified or newly created? How are we to manage distributed resources on the networks? What kind of eLearning standards will be used? How can we support interoperability and scalability of the eLearning system? How do we take into account the technological diversity between groups of users within the target population?

---

[1] Implementation and Deployment of Learning Designs http://www.idld.org

How can we promote reusability, sustainability and affordability of the web-based learning systems we are building?

To address these important questions, a renewed instructional design methodology is needed more than ever. The next section defines and presents the basis of such a methodology, which we call "Instructional Engineering", followed by a brief description of an example of such a method: the MISA method. We conclude this section by stating a set of principles for instructional engineering.

1.1 Foundations for Instructional Engineering

We situate instructional engineering as a methodology to solve a particular class of problems, those aiming at the construction of learning systems that can increase human knowledge, skills and competencies.

These problems share the main characteristics of design problems in other fields such as architecture, engineering or computer science. The input to the design process is a set of general specifications and goals, mostly ill-defined at the beginning, as well as a set of constraints to fulfill. The resulting product is an artefact, here a *learning system*, obtained by defining more and more precise specifications, until they become a set of materials and resources that are considered ready for delivery to the end users.

Basically, instructional engineering lies in the general framework of systems science (Simon 1981; LeMoigne 1995) in which a system is defined as a set of dynamically interacting elements, organized towards a goal. In our case, an instructional engineering method groups a set of design products, tasks and principles organized to support the engineering of a learning system, which is also a system to be used at delivery time by learners and different kinds of facilitators. Instructional engineering integrates features from previous instructional design models as well as processes and principles from both information systems engineering and knowledge engineering as shown in Figure 1)
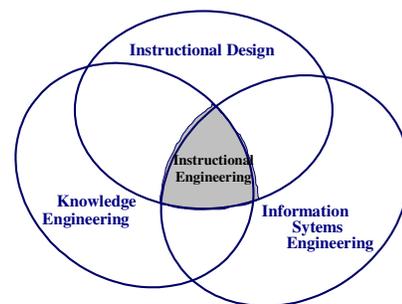

Figure 1 – Systems Design Methodologies

A century ago, John Dewey hoped for the development of a science that could fill the gap between learning theories and educational practice. At the beginning of the sixties, a new discipline, instructional design, was born under the influence of pioneering work from scholars like B.F. Skinner, Jerome Bruner and David Ausubel. In the seventies, several proposals were made for the construction of an instructional theory: explicit conditions of learning (Gagné), a cybernetic approach to instruction (Landa), a structural learning theory (Scandura), Cognitive Apprenticeship (Collins and Stevens), the Component Display Theory (Merrill), and the Elaboration Theory of Learning (Reigeluth and Rodgers). Principles from these theories must be adapted to correspond to new technological and social contexts and to form part of the basis of instructional engineering. Instructional Engineering (IE) is a macro-design methodology preparing

directly integrative web sites or learning portals grouping resources (or learning objects) to support each actor at delivery time.

From a technical point of view, an eLearning system is basically an information system hosting a complex array of software tools, digitized documents and communication services. Similar to the evolution in software engineering, the artisan-like construction of web based materials or the use of simplistic authoring tools are totally insufficient to cope with instructional engineering IE decisions. IE is, in general, used for the construction of complex information systems. Software engineering principles and processes should inspire the general organization of the Instructional Engineering phases as well as the organization of sub-tasks and design documents. This is the case of the MISA instructional engineering method (Paquette et al. 1994, Paquette 2002, 2004) developed at the LICEF Research Centre. The multi-agent view, now dominant in software engineering, is an important way to view an eLearning system as a set of agents, persons, resources and computerized modules, interacting towards a goal, which is to help some of the agents to learn or facilitate learning. This approach corresponds well to new pedagogical possibilities that Web technology offers.

The actual emphasis on knowledge management in organizations recognizes the importance of knowledge and higher order skills, as opposed to simple information acquisition. Knowledge engineering is a well established methodology rooted in the development of artificial intelligence and expert systems. Knowledge elicitation, processing and communication, and also knowledge modeling methods and tools should be at the center of instructional engineering. These will serve to build models of the subject matter, models of learning scenarios, models of learning materials and models of delivery process. In the context of the Semantic Web, knowledge models can take the form of ontologies both to describe the learning domain, as well as the corresponding task ontology.

Finally, even though Instructional Engineering can support any instructional strategies or delivery model, it will be most helpful in the context of constructivist instructional strategies, where learner are actively involved in knowledge and skills construction, through some form of *process-based learning scenario,* such as project-based learning, problem solving or collaborative learning. The methodology takes into account the specific subject matter knowledge and metacognitive skills to process domain specific knowledge, which is being constructed at the same time. A learning scenario for a module should be described, whenever possible, as a generic process, corresponding to a metacognitive skill. In other words, if we want to develop knowledge in a subject matter as well as matching skills, such as classification, diagnosis, induction or modeling, the scenario should consequently propose classification, diagnosis, induction and modeling processes, problems or projects to the learner. For example, in a classification task, sorting tools in a spreadsheet and collaborative classification activities could be embedded in the scenario, matched with assistance taking the form of methodological advice to support the classification process.

1.2 Presentation of the MISA Method

This section presents an instructional engineering method called MISA (Paquette 2002a, 2004). This method is the result not only of research in the field of instructional

engineering, but also of the practical experience acquired through the development of numerous telelearning courses.

This effort started in 1992 and a first version of the method was produced in 1994, embedded in a computerized support system for instructional designers called AGD (Paquette et al 1994). The method was then validated with instructional designers and content experts in nine different organizations and was rebuilt according to results and observations gathered during these validations. In parallel, we have extracted and rebuilt a tool for knowledge modeling (MOT) to support central aspects of the method (Paquette 1996, 2002b). After another round of validation, our attention focused on learning object typologies. We defined seventeen typologies on concepts such as knowledge models, skills, learning scenarios, learning materials, delivery models and so on. In 1998, this effort led to MISA 3.0 in which these typologies are used to present numerous alternatives to the designer on which to build viable design decisions. Also, the method was restructured into six phases and four axes under which the main design tasks have been distributed. The actual MISA 4.0 version has been built in coordination with a web-based design system called ADISA.

MISA 4.0 is organized around 35 main tasks as shown in Figure 2. Because it is a macro-design process, the method produces a full Learning System (LS) model and blueprint, to be instantiated by selecting, adapting or building pertinent learning materials. This macro-design process is decomposed into six phases or processes performed by the designer to progress from general to specific, by providing the definition of the project, the elaboration of a preliminary solution, the design of the instructional architecture, the design and delivery of instructional material, the production and validation of the materials in the learning system, and finally, the planning of the learning system delivery.
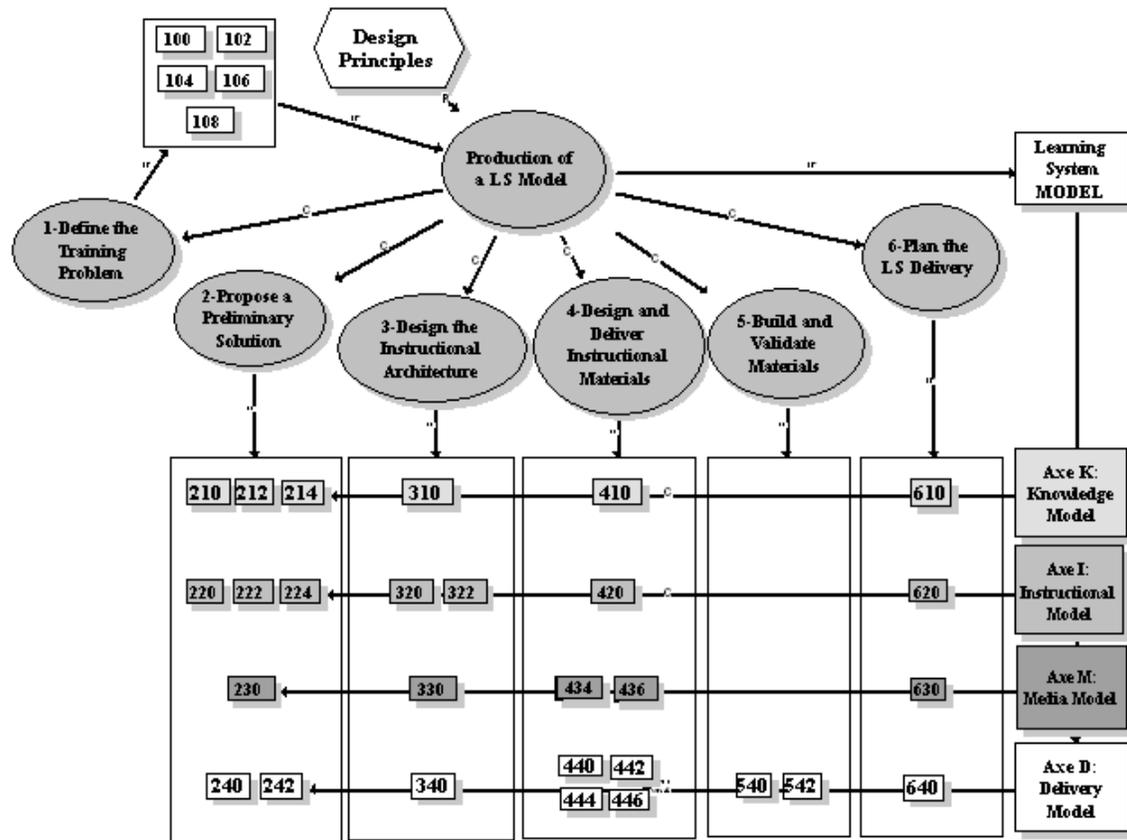
Design Principles

100 102 104 106 108

Production of a LS Model

Learning System MODEL

1-Define the Training Problem

2-Propose a Preliminary Solution

3-Design the Instructional Architecture

4-Design and Deliver Instructional Materials

5-Build and Validate Materials

6-Plan the LS Delivery

210 212 214	310	410		610	Axe K: Knowledge Model
220 222 224	320 322	420		620	Axe I: Instructional Model
230	330	434 436		630	Axe M: Media Model
240 242	340	440 442 / 444 446	540 542	640	Axe D: Delivery Model

Figure 2 – The structure of the MISA 4.0 instructional engineering method[2]

After the preliminary definition and adaptation of the method where only relevant tasks are selected, four axes are deployed in parallel during phases 2 to 6. The first axis aims at the definition of the *knowledge* content (K) that is modeling knowledge and skills to be learned. The second one, *the instructional* model (I)*,* helps define learning events and their actors, scenarios, activities and resources. The third axis describes the *media* model (M)*,* which consists in building a conceptual design of new or adapted learning materials to be built (if necessary). The last axis, the *delivery* model (D), describes actors and their interaction processes at delivery time. These two last axes are not always necessary. For example, if only existing material or learning objects are reused, the media model is not needed unless important adaptations need to occur. Also, if the delivery is mostly classroom based, the delivery model is simple enough and does not need any further elaboration.

Table 1 presents the 35 design tasks classified according to the four axes, except for the initial problem definition phase. Similar to software engineering methods, each axis starts with the statement of orientation or vision principles. Each of these sets of principles in the documentation element DE 210, 220, 230 and 240 are guidelines that the designers state for themselves. These statements also help team members communicate, promote

---

[2] Adapted from (Paquette 2004), p.107

goal directed behaviour and help in maintaining consistency throughout the design process.

Problem Definition		
100 Organization's Training System	104 Target Populations	108 Reference Documents
102 Training Objectives	106 Actual Situation	
Knowledge Model		**Instructional Model**
210 Knowledge Model Orientation Principles		220 Instructional Principles
212 Knowledge Model		*222 Learning Event Network*
214 Target Competencies		224 Learning Unit Properties
310 Learning Unit Knowledge Models		*320 Learning Unit Scenarios*
410 Learning Instrument Knowledge Models		322 Learning Activity Properties
610 Knowledge/Competency Management		420 Learning Instrument Properties
		620 Actors and Group Management
Media Model		**Delivery Model**
230 Media Principles		240 Delivery Principles
330 Development Infrastructure		242 Cost-Benefit Analysis
430 Learning Materials List		340 Delivery Planning
432 Learning Material Models		*440 Delivery Models*
434 Media Elements		442 Actors and User's Materials
436 Source Documents		444 Tools and Telecommunication
630 Learning System/Resource Management		446 Services and Delivery Locations
		540 Assessment Planning
		542 Revision Decisions Log
		640 Maintenance/Quality Management

Table 1– Main instructional engineering task in the MISA 4.0 method

Knowledge modeling using the MOT or MOT+ software is the backbone of the method in each of the four axes. To build a structured view of the general content, a graphic knowledge model is built (212). Then the content of learning units (310) and learning instruments (410) is described as sub-models of the global knowledge model. In the instructional axis, graphic modeling helps represent the structure of the learning events at the course or program level (222), and also each of the scenarios describing the activities in each learning unit (320). In the learning material axis, we model for example a web site or an hypermedia software (432), showing the media components, their interrelations through hyperlinks, the media constraints and templates and the source documents to be displayed. Finally, in the delivery axis, we model (440) by identifying the actors, their roles, their interactions, their input resources and their productions at delivery time. The multi-agent approach is applied mainly through the design of the learning scenarios and, even more directly, while building the delivery models.

Most of the other tasks in MISA describe properties of the objects contained in the graphic models that are the basis of the axis design content. For example, we describe target competencies (214) related to objects in the knowledge model, learning activities (322) or learning instruments (420) as properties of the objects in learning scenarios, source documents (436) in learning materials models, and finally tools, communication links (444) and services (446) in the delivery models.

1.3 Principles for Instructional Engineering

Figure 2 indicates that design principles must guide the design process. This is the most important aspect of an instructional engineering method like MISA. Table 2 summarizes 20 design principles that are only briefly explained here[3]. Our goal is to give the reader an overview of what we mean by a principled approach to instructional engineering.

Learner Self-Management.	Information Processing
1 – Well-structured large enough knowledge models 2 – Knowledge related to generic skills and to competencies 3 – Learning scenarios built upon a generic skill's process model 4 – Open and multiple choice learning scenarios at design time 5 – Instructional model adaptable by learners and/or trainers at delivery time 6 – Explicit activities and support tools for self-management and meta-cognition.	7 – Rich and diversified information resources and learning objects 8 – Dynamic resources for bi-directional communication 9 – Information search guided by process-based scenarios 10– Tools for information search, annotation and restructuring 11– Information production tools adapted to generic tasks.
Collaboration	**Personalized Assistance**
12 – Balanced collaborative and individual activities sustaining each other 13 – Collaborative tasks adapted to the generic process in a learning scenario 14 – Balanced synchronous and asynchronous interactions between learners. 15 – Management tools for group coordination by learners and trainers	16 – Human or computer agent assistance based on the generic process in a learning scenario 17 – Variety of facilitator and facilitating agents 18 – Careful assistance, mainly at the learner's request. 19 – Heuristic and methodological guidances
Coherence	
20 – Coherence between target competencies and the knowledge, instructional, media and delivery models.	

Table 2– A set of Instructional Engineering principles

Self-management principles deal with how the learner analyzes previous knowledge, needed knowledge or desired knowledge, consequently building a view of his/her own knowledge and generic skills. Self-management is a way to encourage meta-cognition. The structure of the knowledge models and the learning scenarios are critical to enable learners to self-manage their activities and thus trigger metacognitive processes that are essential to learning. For example, the first principle states that small knowledge units, isolated knowledge units or a list of unstructured subjects does not provide a good basis for learner self-management. A learning unit should group a sufficient number of interrelated knowledge units: not a single small concept, but a concept with its main components and the procedures where it is used; not a single small procedure but also its inputs, products and control principles; not a single principle, but a set of related principles linked to the procedures they regulate or the concepts they define. Principle 2 recognizes that knowledge, which is specific to a domain and metaknowledge (knowledge about knowledge) are being constructed at the same time (Romisowski 1981, Pitrat 1991). A learning unit without an associated target generic skill or competency is like a set of data without any process acting on it. Other principles in this group state that designers need to provide choices for self-management to occur.

The *information processing principles* focus on the interactions of a learner, with agents providing fuel for thought. These agents are either online content experts, mediated

---

[3] More details are given in (Paquette 2002a)

information sources or learning objects. From an instructional engineering viewpoint, this type of interaction corresponds to information acquisition triggering information processing activities where a generic skill is mobilized. Through these activities, the learner can construct personal knowledge and also, communicate new information he has produced to other learners or decide to ask for assistance. For this, learning scenarios must define clear information goals. The large diversity of information sources can decrease the motivation of a learner in the quest for useful information. To counter this "lost in space" effect, it is essential that the learner has a clear view of the information which is needed. To better understand the goal, it can be given in the learning activity assignment by stating target competencies and success indicators. The most crucial part of the learner's interaction with information is the one where he will process the information to build a product of a learning activity, that is, acquire knowledge. The choice of tools associated to a learning unit depends very much on the generic process on which the activity is based. For example, a planning process will necessitate a spreadsheet or a project management tool, while a taxonomy construction will make good use of a graphic or tree editor.

The *collaboration principles* are concerned with the interaction between and among learners. From a multi-agent perspective, these interactions are defined essentially by the assignment of tasks in a learning activity, the distribution of responsibility between learners and their coordination. The main principle here is balance between collaborative and individual activities, between asynchronous and synchronous collaboration and between generic tasks adapted to the competencies and the specific knowledge to be built.

Finally, the *assistance principles* focus on the interactions between learners and facilitators. Facilitators are resources providing help and assistance to the learning process that can be made available to the learner in different forms: as a check list to consult from time to time, as an intelligent advisor tracing the learner and providing advice, or as a guide to the trainers' interventions towards the learner. Principle 16 states that assistance resources should be based on the principles regulating the generic process on which a learning scenario is constructed. For example, if the scenario proposes a diagnostic project, the trainer assistance should at first assist the learner in the analysis of the component structure of the system under scrutiny, and then only propose methods or pertinent questions. In principle 19, we suggest using "heuristic and methodological assistance" most of the time, where typically, the human trainer or the intelligent advisor system will suggest building tables or graphs, decompose the problem and more generally give advice based on his knowledge of the generic process purported by the learning scenario. This strategy permits the learners to progressively construct their own knowledge model or schemata by avoiding the use of too specific and precise algorithmic guidance, which might, in turn, prevent every mistake, but also give too much of the solution.

2. Educational Modeling: Operational Support

Using the MISA theoretical and methodological framework, this section focuses on educational modeling languages and the IMS-LD standard specification shifting from methodology to operational support.

The term "Educational Modeling Language (EML)" was first introduced in 1998 by researchers at the Open University of the Netherlands (OUNL), as a response to Instructional Design and pedagogical concerns towards standardization and interoperability needs. The work on Educational Modeling Languages (Koper 2005) has led to the adoption by IMS of the Learning Design Specification (IMS-LD 2003), thus integrating Instructional Design preoccupations into the international standards movement. IMS-LD describes a formal way to represent an Instructional Model as a an instantiation of a standardized XML schema that specifies learning scenarios, which structure the roles that learners and facilitators can play, performing activities where they use services and learning objects in environments. The conceptual model also proposes outcomes of an activity; however, the XML does not include this concept.

The IMS-LD specification leaves open the choice of instructional methods and modeling tools that can support designers in the process of building learning designs, as well as the learning materials and environments that will instantiate these models. Figure 3 presents a schematic view of the relationship between the IMS-LD specification and instructional engineering methods and tools, including the MISA method presented in the previous section. Such methods build learning system models. When expressed as a standard IMS-LD XML file, these models can be read by any compliant delivery system, such as learning portals, learning management systems (LMC) or learning content management systems (LCMS), such as the LICEF Explor@ system (Paquette et al 2005b).
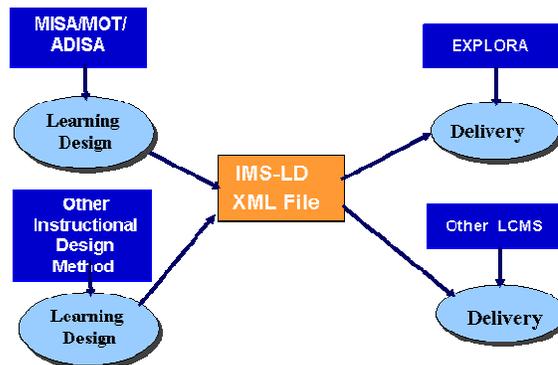

Figure 3 – Interrelations among IE Methods, IMS-LD Designs and Delivery Systems

In fact, the IMS-LD specification corresponds quite well to one of the four models the MISA method, namely the instructional model. We have shown in (Paquette et al. 2005a) that even though both sets of concepts do not correspond exactly, the MISA method qualifies as an educational modeling language. This has two important implications. First, the instructional engineering processes and principles become available to guide the construction of IMS-LD specifications. Second, it is thus possible to use the MISA graphic and form-based tools to produce IMS-LD standard models, providing operational support to implement the specification (De la Teja et al 2005).

To achieve that, we have adapted the MOT+ graphic editor, the main MISA tool, to the IMS-LD semantics. The new MOT+LD graphical editor (Paquette et al. 2006) enables designers to fully describe the structure and concepts in the IMS-LD Level A specification, producing an instance of a standard LD XML schema. In Griffiths and al. (2005), this approach is considered "significant, not only because it provides an example

of a powerful and expressive high-level LD editor, but also because the structure of LD are mapped onto a graphical language which appears to be very remote from the specification". Our aim is to offer instructional designers a more natural way to model learning scenarios and their related concepts than XML code or UML software engineering graphic models.

Figure 4 shows the correspondence between MOT+ graphic symbols and IMS-LD concepts. Resources are represented by five kinds of concepts (rectangles), the LD method components (actions) are represented by seven kinds of procedures (ovals), whereas actors and rules are represented by five kinds of principles (hexagons). Individual objects are represented by clipped rectangles (called "facts" in MOT+) representing learning objectives and prerequisites, metadata, items, and four other types of objects needed to describe conference, send-mail and index-search services.

The same basic links as in the general MOT language (Lundgren-Cayrol K. and Léonard M. 2006) can be used; however, a number of new constraints on links between subtypes were added in order to comply to relationships specified in the IMS LD Information and Binding model in order to produce a valid XML manifest file. A post-validation mechanism was built into the XML translator informing the designer whether an IMS-LD rule has been violated and where to find it in the model. The number of possible violations was reduced by limiting the choice of possible links between sub-types according to the IMS-LD constraints alerting the designer to these while conceiving the model.
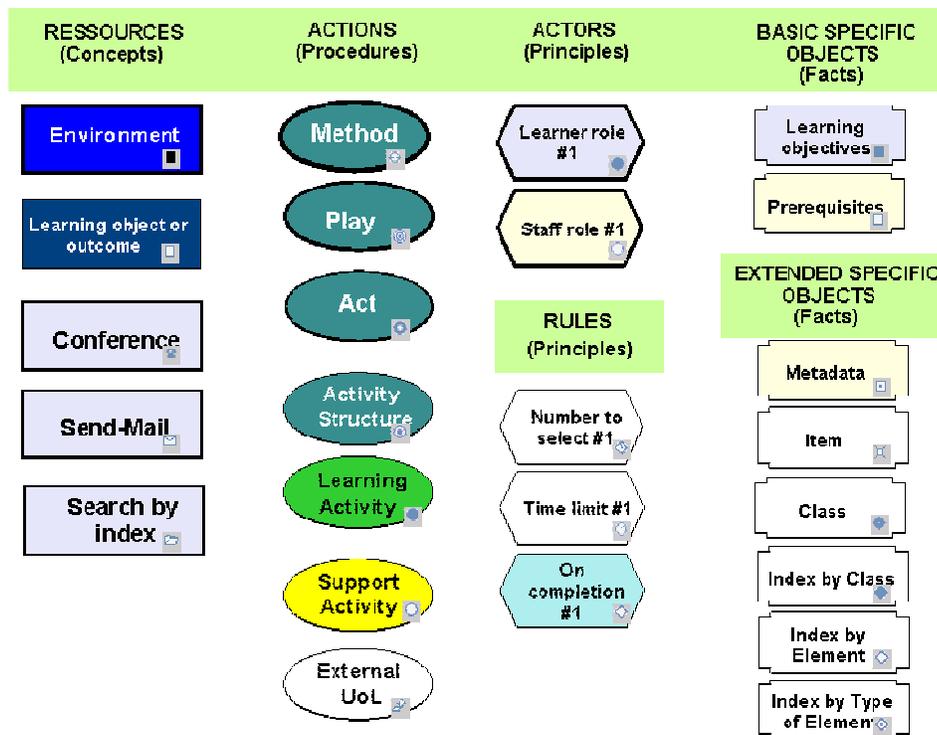

Figure 4 - **MOT+LD basic vocabulary**

Figure 5 shows an example of a MOT+LD model for the Versailles unit of learning proposed by the IMS-LD team[4]. In this unit of learning, students are organised in 6 groups corresponding to the 6 countries negotiating the Treaty of Versailles at the end of World War I. A single Play is composed of (C links) 8 Acts ordered sequentially (P links). Act 6 is composed of several activity structures describing the negotiation day for each country. The left-hand graph, in Figure 5, shows one of these negotiation models. Finally, each of the learning activities within this activity structure is structured the same way, as illustrated by the smaller model in the bottom right hand corner. This model presents the France-Serbia side-room discussion in an environment composed of a conference service and a discussion activity as well as their items pointing to corresponding concrete resources.
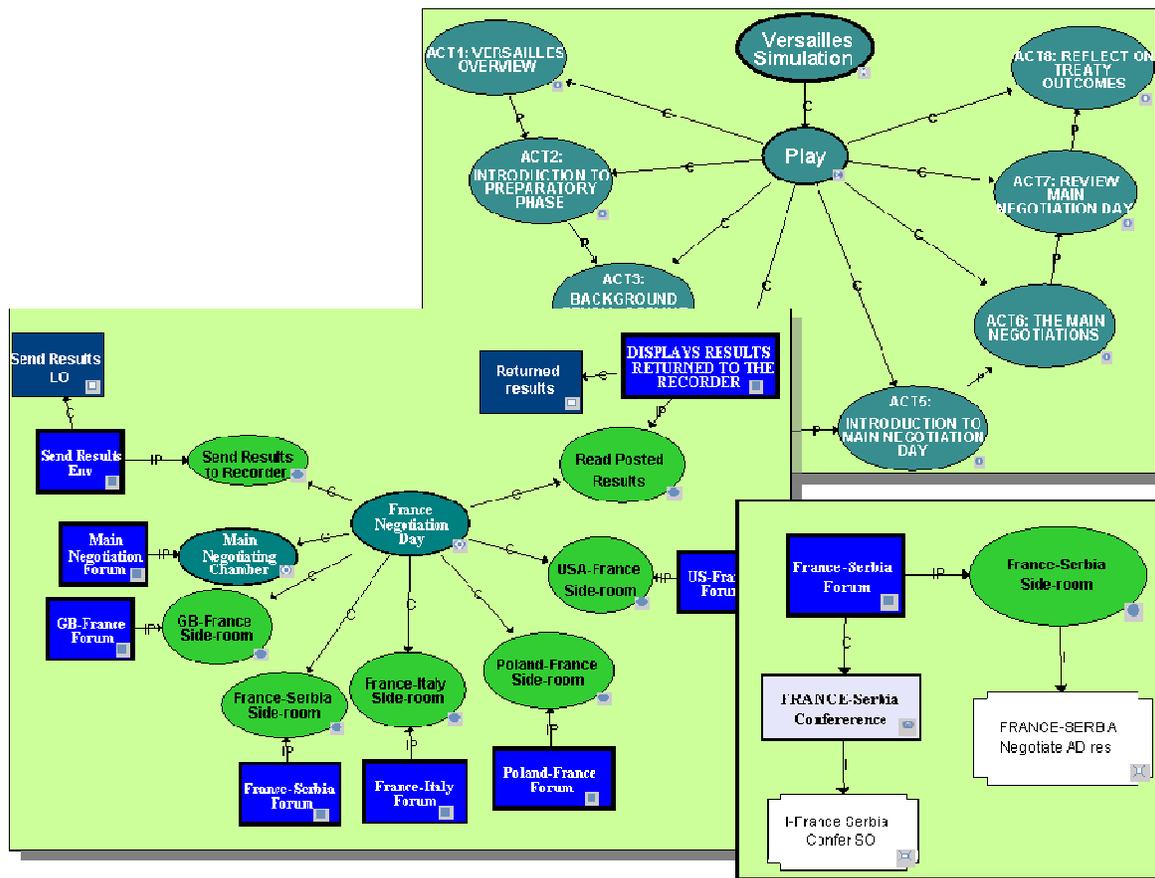

Figure 5 - **A MOT+LD unit-of-learning (The Versailles example)**

3. Reusability-Centered Designs for Viability

This section addresses the question of viability by discussing the integration of learning objects to learning scenarios, while addressing the concern of reusability of both learning objects and learning scenarios. We treat this issue by analyzing a use case where an

---

[4] For more information please consult: IMS LD Best Practices, section 4.2. p.50-75,
http://www.imsglobal.org/learningdesign/ldv1p0/imsld_bestv1p0.html

existing Télé-université course, designed using the MISA method, was initially transposed into a graphic MOT+LD model. Later on in the process, this standardized model was made generic, then decomposed into smaller generic units of learning (UoL) or scenario templates, also named nuggets (Bailey et al, 2006). All these UoL were stored as learning objects in the Canadian LD repository (Paquette et al. 2005)[5]. At this point the learning object repository can be searched for UoL templates to be combined into larger templates that are put back as learning objects in the repository. Finally, a new search can be done in the repository, this time for content or tool objects, to instantiate the scenario possibly in different subject matters. Let us review this use case in more detail.

1 – Building a MOT+LD standard model for a course. Since the course was initially developed applying the MISA method, a MOT model was available. This model was imported directly in the MOT+ editor and adapted using the MOT+LD graphic objects and links presented above. Creating completely new courses, the models are created directly in the MOT+LD editor, guided by the MISA method. Figure 6 presents the structure of the course (Method, Play and Acts) divided in 8 acts. The second graph represents an activity-structure within Act 2.
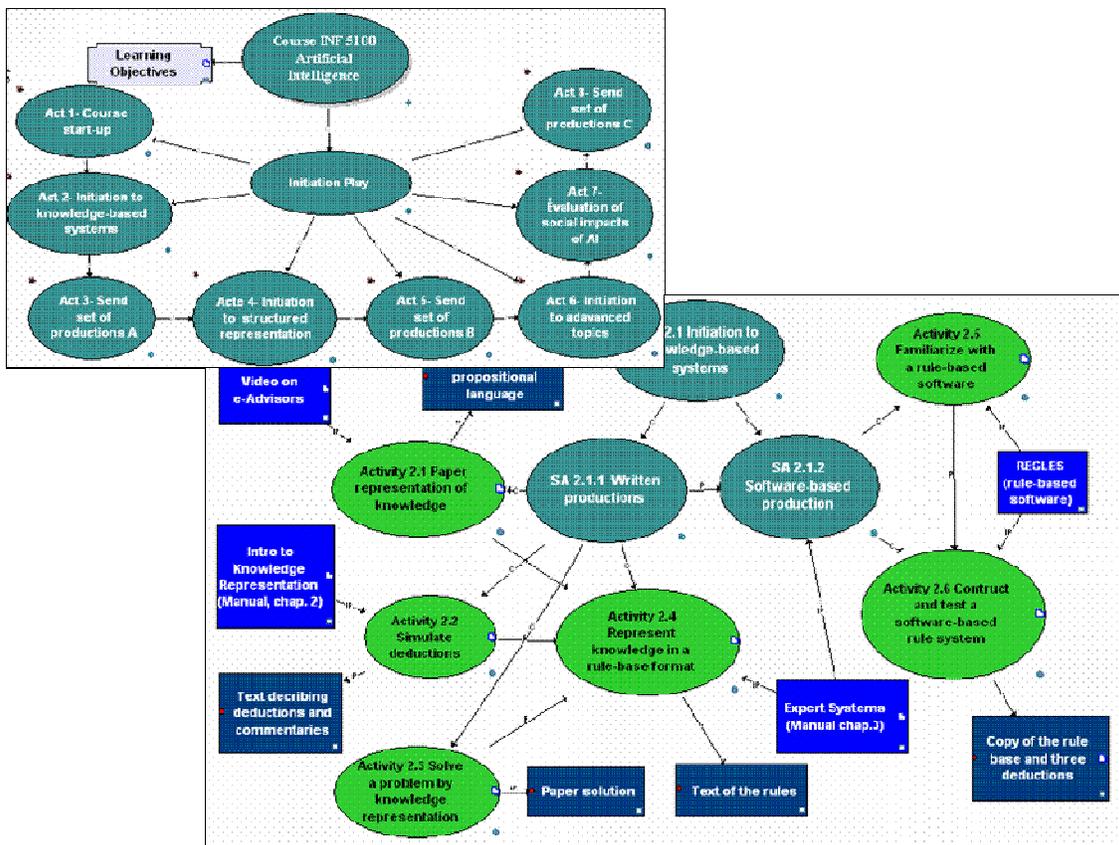

Figure 6 - **Part of the MOT+LD model for the course on Artificial Intelligence**

---

[5] For more information see http://www.idld.org/

2 – Obtaining a scenario template, as well as content and tool learning objects. In this phase of the process, the learning design model is made generic by just removing all the items associated to graphic objects. These items provide the address of concrete resources associated to the objectives, the activity assignment, the texts, the videos and the software tool illustrated in Figure 7. In MOT+LD, addresses can be seen by right-clicking on the corresponding graphic symbol, the item object. If they were not already in the metadata repository, they could have easily been added using the PALOMA repository manager. Once these item objects are removed, a generic scenario template is obtained. It is then sufficient to rename the objects with generic terms free of AI content as shown on Figure 7, and store this scenario template into the PALOMA repository, both as a XML Level A manifest file and a graphical scenario. It is also possible to convert the graph to an html file to dynamically view the Unit of Learning Model and sub-models.
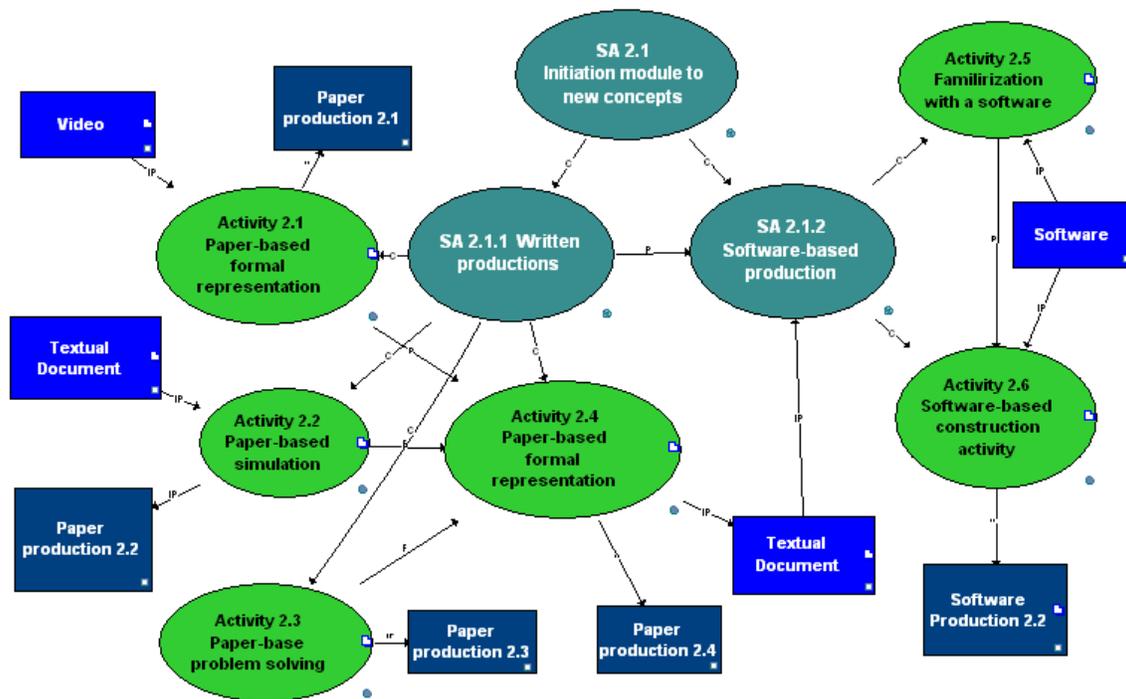

Figure 7 - **A MOT+LD generic scenario template**

3 – Decomposing the course template into basic smaller UoL templates. While analyzing the whole course, we noted that it could be rebuilt using only five basic UoL templates. For example, the graph in Figure 7 contains two basic templates: WRITTEN PRODUCTION for activities 2.1 to 2.4) and SOFTWARE PRODUCTION for activities 2.5 and 2.6. These two templates are also present in act 4 and 6 of Figure 6). A third basic template is used to STARTUP an online course, in Act 1 of Figure 6. A fourth template is needed for HOMEWORK DEPOSIT in act 3, 5 and 8 of Figure 6. Finally, a last template is needed for the SYNTHESIS FORUM in act 7 of Figure 6.

Figure 8 shows a list of such templates referenced in the PALOMA learning resource manager. The left pane shows a list of repositories. The center pane presents the titles of a set of learning designs resulting from a search in the repository according to some metadata. The right pane presents the metadata of the selected object, here the

"SYNTHESIS FORUM" scenario template. By clicking on the "eye" button, the MOT+LD model can be displayed and selected to be used in the aggregation process.
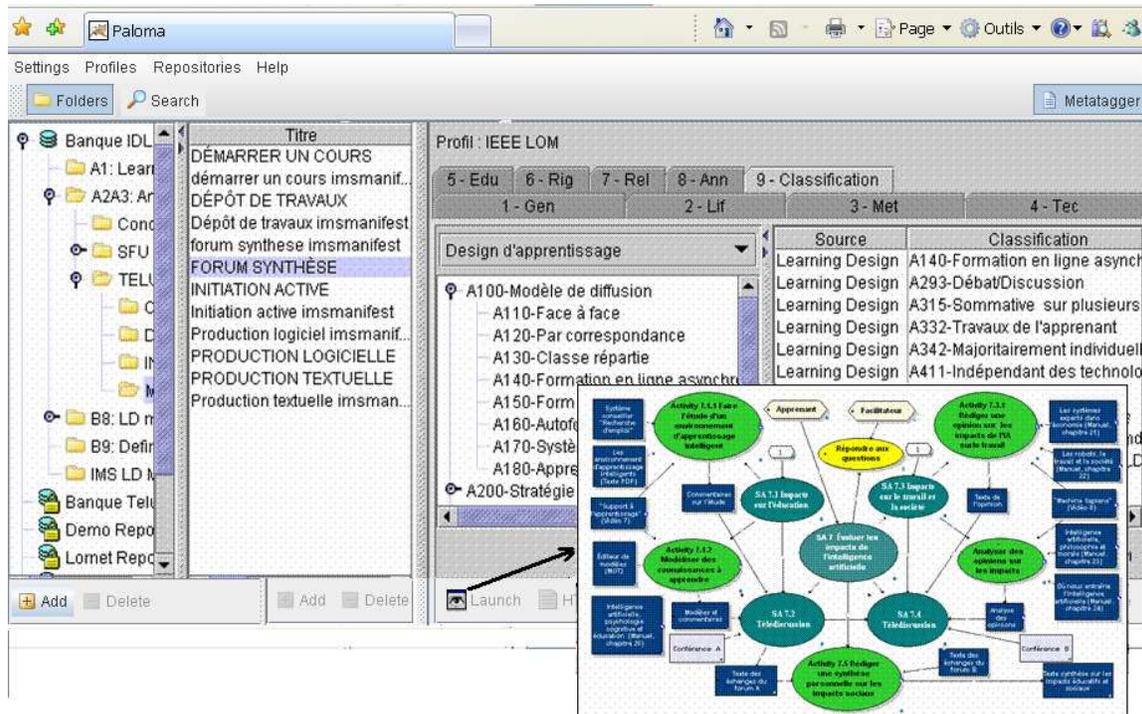

Figure 8 - A set of learning design objects referenced in a PALOMA metadata repository

4 – Re-composing new MOT+LD course templates. By re-composing the five basic templates obtained at the preceding step, it is possible to build a new UoL corresponding exactly to the course template produced in step 2, which confirms the reusability of such templates. It is also possible to modify the structure to provide alternative plays, for example a course template with only five acts, or another with 8 acts but with more difficult activities for more advanced students.

5 – Instantiating a course template into different knowledge domains and contexts. Once a course template is obtained by grouping smaller grain templates, a search in the PALOMA repository will provide links to content objects (text, videos, etc.), tool objects (software), assignment texts or learning objectives that can be associated as items to the graphic LD objects in the model. For example, the initial artificial intelligence course structure, or another one built in step 4 for another context, can be instantiated back into the AI knowledge domain using new AI resources. They can also be instantiated in completely different domains like Politics or Physics by selecting content, tools, assignments or learning objectives objects in these knowledge domains.

The interesting thing about this use case is that it shows how simple manipulations on graphic models can rapidly populate learning object repositories with learning design patterns (the generic scenario templates) as well as with content, tool, activity and learning objective resources. Then using federated search provided by tools like PALOMA, into a network of repositories, it becomes possible to reuse, structure and integrate all kinds of resources into new meaningful modules and courses that can be

played directly on any IMS-LD compliant delivery system. This is a strong argument for the viability of the general approach presented here.

4. Delivery, Implementation and Dissemination Issues

The process presented in section 3 is an interesting proof of concept but there are still many problems to solve in order to arrive at an efficient practical process that can improve the quality of learning designs.

In this section the delivery, implementation and dissemination issues that have emerged during the Canadian Implementation and Deployment of Learning Design project, IDLD,[6] are discussed. In this project we elaborated a general methodology for transposing, creating and adapting learning scenarios into fully compatible IMS LD units of learning.

In the first phase, our research group's tools, documents and expertise were used by three other teams besides Télé-université, at Concordia University and at Simon Fraser Universities, and also one at the Canada School of Public Service to build standardized learning designs.   The two main standards needed for the implementation and deployment of Units of learning are the IMS Learning Design Specification and a metadata schema, in our case Learning Object Metadata Standard by IEEE. This helped build, in the PALOMA Resource Manager, a repository of around 50 learning designs. The IDLD (www.idld.org) gives access to this repository as well as to the documents, methodological aids, software tools and reference sites used or developed during the project.

In a second phase, a testbed was carried out with new instructional designers distributed all over Canada to test the use of the IDLD repository and portal for learning design operations. This testbed yielded ample information not only on implementation and deployment issues, but also on the types of reuse that are potentially viable.

The implementation and deployment process that was elaborated during the experimentation is both collaborative and iterative. Face-to face events as well as email and other communication services were used to support the teams. Moreover, several examples were available in the repository.

Throughout this process, the teams were involved in the following activities:
1. Familiarization: Explanation of main IMS LD concepts and paradigms and the demonstration of MOT+LD editor.
2. Planning: Clarification of the context at hand and construction of a plan on how to best implement and deploy IMS Learning Designs.
3. Preparation: Analysis of existing courses to be modeled by respecting a number of principles such as :
    a. Constructivist or cognitivist learning paradigms;
    b. Collaborative learning strategies in a blended or online learning setting.
    c. Multi-actor design, making use of content/field experts, teachers moderators etc.
    d. Generic and/or easily adapted learning environment;

---

[6] See http://www.idld.org

   e. Ensure instructional quality by applying a known ID method, i.e., MISA
4. <u>Implementation</u>: Model building supported by mentor activities and community exchanges through the following steps:
- *Face- to face workshop:* Participant training, where the objective was to explain the constraints required by the IMS LD specification and to demonstrate the MOT+ LD editor tool.
- *Exemplification*: Presentation of IMS LD narratives and derived units of learning models and xml files;
- *Drafting*: Elaboration of a first draft of the chosen course;
- *Face-to face workshop:* Validation of this first model and demonstration of advanced features of the MOT+ LD editor.
- *Modeling Support*: Discussion of alternatives to the proposed solutions and continuous coaching in the modeling process.

5. <u>Validation</u>:
- Exportation of the MOT+LD Level A model as an xml manifest file and testing it in an IMS-LD compliant player, such as RELOAD Player.
- Summarizing and documentation of impressions.

6. <u>Referencing</u>:
- Publishing the Unit of Learning and indexing them using a recognized metadata scheme.

Table 3 shows problem areas for each of the issues as well as some principles to reduce the effect them.

Issue	Problem area	Principles
IMS LD Implementation and deployment	Pedagogical viability • Complexity of LD • Foreign to actual practices • Conceptual confusions – mixing pedagogy with delivery strategies	• Provide guidelines for the use of the IMS-LD concepts and the modeling editor. • Clearly explain the issues of reusability, such as – Technical interoperability and metadata tagging – Storing of the learning object – Structured narrative of UoL • Involve the technological department in the project • Add a glossary of terms explicit enough to avoid confusion • Identify the new competencies required in this approach
Delivery process and tools	Technical Viability • Editors and authoring systems • Publishing tools Referencing • Learning a new technology	• Plan a minimum of a two day training session to develop autonomous LO designers • Make tools more transparent and intelligent • Provide a variety of examples including explanations on the process of adaptation

Dissemination Issues	Reuse • Interoperability • Intellectual property and copyright • Usage data	• Be sure all installation requirements and other technical issues are documented in the metadata of the UoL • Provide evaluation criteria and adaptation principles to facilitate reuse • Introduce the Creative Commons[7] to protect illegal/unwanted use and secure authors • Provide usage data by annotation and recommendation.

Table 3 – Issues, problem areas and effective principles for sustainability

In conclusion, the case studies and the testbed allowed identifying several important principles in order to ensure quality, viability, dissemination and reuse.

5. Conclusions: Research Trends

The work presented in this chapter shows that research in the field of Technology Enhanced Learning have progressed rapidly in the direction of the goals we have mentioned in the introduction. On one hand, software engineering concerns such as formal specification, reusability and interoperability have made their way in this community and are here to stay.

On the other hand, the problem of designing and delivering technology enhanced learning is now widely recognized as being a complex task in which different dimensions or concepts have to be modelled separately and harmoniously integrated. Either explicitly like in our four axes MISA method or more implicitly, as in the IMS Consortium specifications partition, researchers and practitioners are considering distinct but interrelated concepts such as learning scenarios; knowledge and competency models; learner model; media, resources or learning objects model; evaluation model; assistance model and so on. This separation of concerns has allowed for a better understanding of these dimensions and a more precise specification of technological requirements both at design and at delivery time, allowing new technologies to be effectively tested and integrated into rich learning environments.

Where to go from here? Lots of work is still to be done. We will exemplify this variety by presenting some of the research directions carried on in our team (CICE[8]). The first very active orientation addresses the competency and knowledge models. Our team is actively working on the specification, modelling and instrumentation of such models as well as on the integration of these models to include competency modelling (Paquette 2006, Ruelland et al 2005) and ontology construction to enable semantic annotation and search (Rogozan and Paquette 2005) as well as ontology-driven architectures (Magnan et Paquette, 2006). We are exploring the concept of competency equations (Paquette et Rosca 2005) to create the best configuration of learning activities, learning objects and

---

[7] http://creativecommons.org/

[8] CICE is the Canada Research Chair on Instructional Cognitive Engineering to which the authors are all participating.

teaching support agents, to help a learner acquire a set of knowledge units and to develop adequate competencies.

A second direction is the work being done around the learner model both from a cognitive and from a social perspective; a learner model should be evolving; it should integrate the perception of the different actors of the learning process and it should include the different learning domains and competencies of the learner (Moulet et al 2006).

A third research direction concerns the learning scenarios: starting from the work presented here on scenario modeling, decomposition, re-composition and indexation, our work will continue around the issues of learning scenario patterns, alignment of learning processes with working processes for in-work learning (Marino et al 2006), and design and delivery of process oriented versus community oriented learning situations. Finally, from an engineering point of view, our research concerns the design and development of adaptable, ontology guided learning platforms (Magnan and Paquette 2006). Last but not least, research and development products have to be delivered to and validated by final users.

A fourth direction is focused on learning objects and resources. It involves partners from the GLOBE community on quality assurance strategies in Learning Object Repository practice (Lundgren-Cayrol et al 2006). The goal is to identify and compare the elements of a quality assurance process that are applied by the major learning object repositories and propose an integrated process and instrumentation to ensure the quality of learning objects, before, during and after their inclusion in a repository.

These research directions all converge to the development of TELOS (Paquette et al 2006), a service-oriented and ontology-driven assembly system to help build eLearning platforms and applications. These tools are also validated and explored in a number of tests beds and work engaged in community building and support, such as the deployment and validation processes started in the IDLD project.

References

Bailey, Chris, Zalfan, Mohd T., Davis, Hugh C., Fill, Karen and Conole, Grainne (2006) *Panning for gold: designing pedagogically inspired learning nuggets.* Educational Technology and Society, 9, (1), 113-122. http://eprints.soton.ac.uk/19642/

De la Teja, I., Lundgren-Cayrol, K and Paquette, G. (2005). *Transposing MISA Learning Scenarios into IMS Units of Learning*. Journal of Interactive Media in Education (Advances in Learning Design. Special Issue, eds. Colin Tattersall, Rob Koper), 2005/13. ISSN:1365-893X [jime.open.ac.uk/2005/13].

Gerry G. (1997) *Granting Three Wishes Through Performance-Centred Design*, NATO Communications of the ACM, volume 40, number 7, pp.54-59, 1997.

Griffiths, D., Blat, J., Garcia, R., Votgen, H., & Kwong, KL. (2005). *Learning Design Tools*, in R. Koper & C. Tattersall (Eds.). Learning Design - A Handbook on Modelling and Delivering Networked Education and Training, Springer Verlag, pp. 109-136

Gustafson (1993), *Kent L. Instructional Design Fundamentals: Clouds on the Horizon*. In Educational Technology. February 93.

IMS-LD (2003) *IMS Learning Design. Information Model, Best Practice and Implementation Guide, Binding document, Schemas*. Retrieved October 3, 2003, from http://www.imsglobal.org/learningdesign/index.cfm

Koper, R. (2005). *An Introduction to Learning Design*, in R. Koper & C. Tattersall (Eds.). Learning Design - A Handbook on Modelling and Delivering Networked Education and Training, Springer Verlag, pp. 3-20

Lemoigne J.L. (1995) *Les épistémologies constructivistes.* PUF, Que sais-je? 127 pages, 1995.

Lundgren-Cayrol K., Paquette G. and Lapointe S. (2006) *Quality Assurance Strategies for High Quality Learning Objects.* Proceedings of the MERLOT MIC-06 conference. Ottawa.

Lundgren-Cayrol K. and Léonard M. (2006) *IDLD Modelling Technique* (2006)http://www.idld.org/Methodology/tabid/174/Default.aspx

Magnan, F. and Paquette, G. (2006) TELOS: An ontology driven eLearning OS, SOA/AIS-06 Workshop, Dublin, Ireland, June 2006

Marino O. , Casallas R., Villalobos J., Correal D. and Contamines, J. (2006) *Bridging the Gap between e-learning Modeling and Delivery through the Transformation of Learnflows into Workflows* , in S. Pierre (Ed) E-Learning Networked Environments and Architectures: a Knowledge Processing Perspective, Springer-Verlag.

Moulet L., Marino O. Hotte R, (2006) *Holistic, Evolving and Multi-viewpoints Learner Model*, i2LOR-06 Conference, Montreal, November 8-10, www.lornet.org.

Paquette G. (2006) *Building Graphical Knowledge Representation Languages - From Informal to Interoperable Executable Models*, i2LOR-06 Conference, Montreal, November 8-10, www.lornet.org.

Paquette (2004) Paquette, G. *Instructional Engineering for Network-Based Learning.* Pfeiffer/Wiley Publishing Co, 262 pages.

Paquette, Gilbert (2002a) *L'ingénierie du télé-apprentissage, pour construire l'apprentissage en réseaux*, 450 pp, Presses de l'Université du Québec.

Paquette, Gilbert (2002b) *Modélisation des connaissances et des compétences, pour concevoir et apprendre*, 357 pp, Presses de l'Université du Québec.

Paquette G. (1996) *La modélisation par objets typés: une méthode de représentation pour les systèmes d'apprentissage et d'aide a la tâche.* Sciences et techniques éducatives, France, avril 1996.

Paquette, G., Rosca. I, Mihaila S. and Masmoudi A. (2006 in press) *TELOS, a service-oriented framework to support learning and knowledge Management* in S. Pierre (Ed) E-Learning Networked Environments and Architectures: a Knowledge Processing Perspective, Springer-Verlag

Paquette, G., Léonard M., Lundgren-Cayrol K., Mihaila, S. and Gareau, D. (2006) *Learning Design based on Graphical Knowledge-Modeling* , Journal of Educational technology and Society ET&S , Special issue on Learning Design, January 2006

Paquette G., O. Marino, I. De la Teja, K. Lundgren-Cayrol, M. Léonard, and J. Contamines (2005) *Implementation and Deployment of the IMS Learning Design Specification*, Canadian Journal of Learning Technologies (CJLT), http://www.cjlt.ca/

Paquette, G., De la Teja, I., Léonard, M., Lundgren-Cayrol, K., & Marino, O. (2005a). *How to use an Instructional Engineering Method and a Modelling Tool*, in R. Koper & C. Tattersall (Eds.). Learning Design - A Handbook on Modelling and Delivering Networked Education and Training, Springer Verlag, pp. 161-184

Paquette,G., Marino, O., De la Teja, I., Léonard, M., Lundgren-Cayrol, K., (2005b). *Delivery of Learning Design: the Explor@ System's Case*. In R. Koper & C. Tattersall (Eds.). Learning Design – A Handbook on Modelling and Delivering Networked Education and Training, Springer Verlag, pp. 311-326.

Paquette, G. et Rosca. I. (2004) *An Ontology-based Referencing of Actors, Operations and Resources in eLearning Systems.* SW-EL/2004 Workshop. Einhoven, August 2004

Paquette G., Aubin C. and Crevier, F. (1999) *MISA, A Knowledge-based Method for the Engineering of Learning Systems.* Journal of Courseware Engineering, vol. 2, August 1999.

Paquette G., Crevier F., Aubin C. (1994) *ID Knowledge in a Course Design Workbench.* Educationnal Technology, USA, volume 34, n. 9, pp. 50-57, November 1994.

Pitrat J. (1991) *Métaconnaissance, avenir de l'Intelligence Artificielle.* Hermès, Paris.

Reigeluth C.(1983) (Editor) *Instructional Theories in Action: Lessons Illustrating Selected Theories and Models.* Hillsdale, NJ, Lawrence Earlbaum.

Rogozan D., and Paquette G.. (2005) *Managing Changes to Ontology Versions to Maintain Referencing Integrity on the Semantic Web*, WI-2005 Conference.

Romiszowski A. J. (1981) *Designing Instructional Systems.* Kogan Page London / Nichols Publising, New York, 1981.

Ruelland, D., Brisebois A. and Paquette G. (2005), *Supporting Self-Assessment in a Competency Approach to Learning*, eLearn-05 Conference, Vancouver, October 2006

Simon H.A. *The sciences of the artificial.* (1981) The MIT press, Cambridge Mass.