Web-based Support for the Instructional Engineering of E-learning Systems

By

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Abstract

The rapid evolution of e-learning models increases the number of decisions that have to be made when developing web-based learning systems. ADISA is a web-based system for a project team designing a e-learning system while working on the web. It is based on the MISA method that defines 35 main tasks through which the user produces the design specifications of a learning system, describing knowledge, skills and competencies, learning scenarios, activities and resources, learning materials, and finally, the delivery processes. The innovation in MISA and ADISA is three-fold. a) A key component of ADISA is its object-oriented knowledge modeling approach sustained by a graphic model editor. b) The processes embedded in the method encompass all the dimensions of a telelearning system. c) Software engineering principles are integrated to support systemic design by the project team. The paper describes both the pedagogical and technical aspects of the ADISA system.

1. Principles for instructional engineering

We first define instructional engineering as *a method for the analysis, design, development and delivery planning of computer-based learning systems, integrating concepts, processes and principles of instructional design, software engineering and cognitive modeling.*

There is a growing need for such a methodology because the advances in instructional technologies entail a large set of interrelated decisions to make when we build a telelearning system. What kind of telelearning delivery model or what mix of models do we need? Will we support learners and trainers anywhere, anytime, at any pace? What kind of learning scenarios is useful for a course? Should these scenarios be predefined, propose several 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 in the system? Will we use a multimedia or a plurimedia approach? How are we to manage the distributed resources? What kind of learning object standards will be used? How can we support interoperability and scalability of the telelearning system? How do we take in account the technological diversity between groups of users within the target population? How can we promote reusability, sustainability and affordability of the web-based learning system we are building?

In light of these questions, instructional design (ID) methodology has a more important role to play than before, but we also need a new generation of ID methods, based on the following principles:

- *Information system approach.* A Telelearning system is an information system, a complex array of software tools, digitized documents and communication services. The artisan-like construction of web based materials and the use of simplistic authoring tools is totally insufficient. Similar to the evolution in software engineering, systematic design processes must support telelearning systems design.
- *Knowledge based design.* The actual emphasis on knowledge management in organizations leads to the recognition of knowledge and higher order skills (competencies) as major training goals, as opposed to simple information acquisition. Knowledge engineering is now a well-established methodology rooted

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in AI and expert systems research and practice. Knowledge modeling methods and tools should be at the center of the new ID methodology, in relation to the knowledge management processes.

- *Multi-agent systems.* To be called multi-agent, a system must satisfy four properties [Sycara 1998]. First, the agents, components of the system are situated in one environment. Second, they are autonomous, they control their actions and states. Third, they are adaptive, reacting to change in a flexible way, taking goal-driven initiatives, learning from interactions with other agents. Finally, they are sociable, collaborating and coordinating themselves with users or other software agents. Multi-agent systems offer a good way to model a telelearning system to help define the actors, their functions and roles, and also their interactions as a society of agents.

- *Plurimedia material and macro-design***.** A plurimedia material is a set of large grained digitized files delivered on different supports: print, CD-ROMs, DVDs, web servers, etc. The emphasis on fine grained, closely structured multimedia, will decrease as designers prefer to interoperate existing videos, textbooks, courseware materials waiting to be digitized. Instructional engineering shifts the attention from multimedia micro-design to macro-design of learning scenarios integrating plurimedia materials reusing many available corporate documents and tools.

- *Constructivist pedagogy* based on projects, problem solving and process-centered environments is necessary to promote the acquisition of higher skills & competencies, but it is difficult to encompass in an ID method. This can be done by proposing problem/project based scenarios where the learner will need to use analyzing, synthesizing or evaluating skills. Theses processes will, in turn, orient the search for "just-in-time" and situated information instead of "just-in-case information", wasting a lot of time transmitting masses of information to be memorize, understood and applied at a later occasion. Figure 1 compares these two kind of instructional strategies.

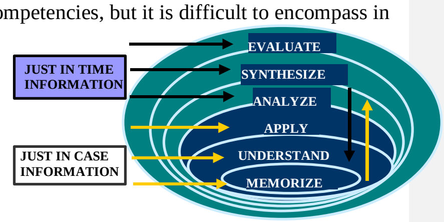

Figure 1 – Hierarchy of skills and information

2. Outline of the MISA instructional engineering method

Based on the principles summarized above, we have built, during the past eight years, a new instructional engineering method called MISA. The first version of the method was completed in 1994. It was embedded in a computerized support system for designers called AGD [Paquette et al 1994, 99].

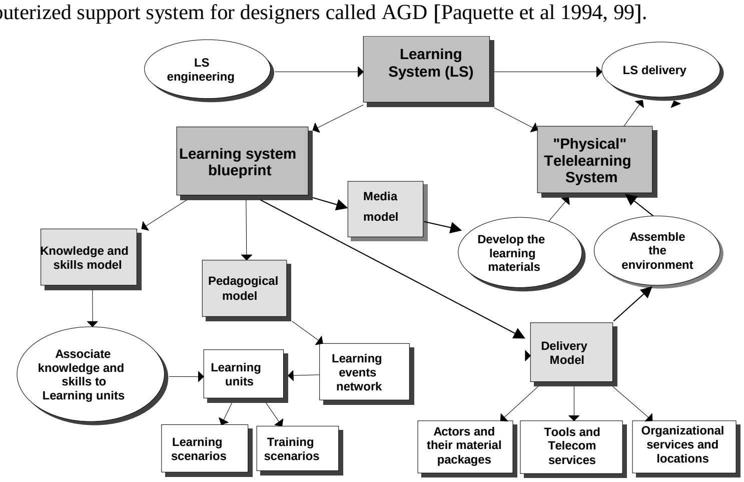

Figure 2 - Learning system engineering concepts

The MISA instructional engineering method is based on the concept of a learning system presented in figure 2, where ovals represent design processes and rectangles their inputs and outputs. MISA 4.0 helps design a learning system through 35 tasks (shown in table 1) producing 35 main deliverables called documentation elements (DE). The method unfolds through six well-defined phases, the first digit of a task number identifying the phase. Except for the initial phase of instructional problem definition, these phases integrate four blueprints or axis (identified by the second digit): 1-knowledge, 2-pedagogy, 3- materials and 4-delivery. Table 1 shows the content of each of theses four blueprints.

Problem definition		
100 Organization’s training system	102 Training objectives 104 Target populations	106 Actual situation 108 Reference documents
Knowledge Blueprint	**Instructional Blueprint**	
210 Knowledge modeling principles	220 Instructional principles	
212 Knowledge model	222 Learning events network	
214 Target competencies	224 Learning units properties	
310 Learning unit content	320 Instructional scenarios	
410 Learning instrument content	322 Learning activities properties	
610 Knowledge and comptency management	420 Learning instruments properties	
	620 Actors and group management	
Learning Materials Blueprint	**Delivery Blueprint**	
230 Media principles	240 Delivery principles	
330 Development infrastructure	242 Cost-benefit analysis	
430 Learning mateirials list	340 Delivery planning	
432 Learning materials models	440 Delivery models	
434 Media elements	442 Actors and user’s materials	
436 Source documents	444 Tools and telecommunication	
630 Learning system and ressource management	446 Services and delivery locations	
	540 Assessment planning	
	542 Revision decisions log	
	640 Maintenance and quality management	

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

Similar to software engineering methods, each blueprint starts with the statement of orientation principles. Each of these sets of principles in 210, 220, 230 and 240 are guidelines that the design team establishes to coordinate their work in a coherent way. These principles establish communication between team members, promote goal directed behavior and help in consistency maintenance throughout the design process.

In each of the four axis, a central task is to build one or more graphical models. These models are the backbone of the method. We build a structured view of the target knowledge and skills (212), followed by their distributions into learning units (310) and learning instruments (410). These models are described using a knowledge modeling technique called MOT [Paquette, 1996], where four types of knowledge objects and seven types of links are available to formalizing a model. In the instructional axis, process modeling is used to represent the structure of the learning events at the course or program level (DE 222), as well as the learning scenarios describing the activities in a learning unit (DE 320). In the learning material axis, we model (DE 432) for example a web site or an hypermedia software, showing the media components, their interrelations through hyperlinks, the media templates and the source documents to be displayed in the material. Finally, in the delivery axis, we model (DE 440) the actors, their roles, their interactions, their input resources and their productions.

Most of the other tasks in MISA describe properties of the objects contained in the models of the axis where they belong. For example, we identify target competencies (DE 214) related to objects in the knowledge model. Learning activities (DE 322) and learning instruments (DE 420) are properties of the objects in the learning scenarios. Source documents (DE 436) describes objects in the learning material models and, finally, tools and telecommunication services (DE 444) describe objects in the delivery models.

MISA 4.0 has been redesigned while building a web-based computer system called ADISA, a distributed system for the instructional engineering of learning environments. We will now describe this system.

3- ADISA – A web-based workbench for instructional engineering

ADISA is a distributed system developed to enhance the performance level of instructional designers, and specifically to assist teams who create Internet-based distance courses or who use sophisticated multimedia technology. This system includes productivity enhancement tools that reduce effort and cost of instructional engineering while maintaining quality consistency and control throughout the various components of a learning system. MOT, an object-oriented knowledge model editor, is a key component of ADISA, making it the first complete knowledge based instructional design tool.

ADISA integrates a large set of educational knowledge embedded including 17 typologies of educational concepts of the MISA 4.0 method integrated menus offering various options to the designers to built some of the DEs. In the case of knowledge models types, a library of models can be made available to the designer as a starting point and later modified in order to adapt to the specifics of the learning situation.

As shown on Figure 3, ADISA is accessible through a Web browser. The left part of the screen gives access to the tools supporting MISA tasks through a table corresponding to the 35 documentation elements of the MISA method. The right part of the screen displays a tool allowing to build the selected documentation element. Here the MOT graphic modeling tool enables the designer to build the Learning Event Network (DE 222) which is a graph representing the structure of a course subdivided here into seven modules or learning units. Other DEs are DHTML forms describing properties of objects in such a model.

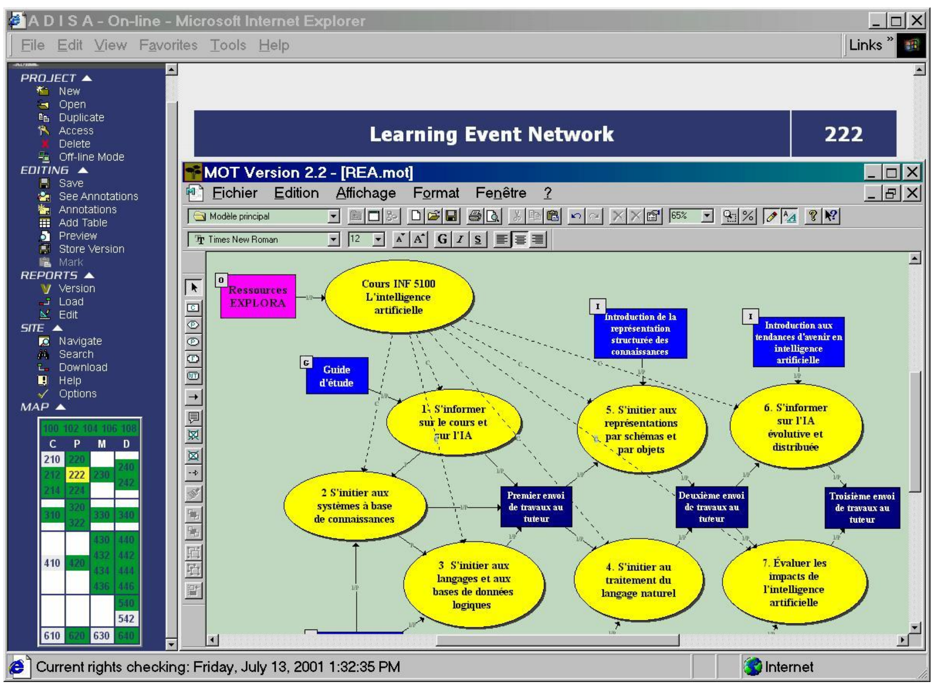

Figure 3 – ADISA screen for DE –222 to build the Learning Event Network

Besides the DE card display, the four menus on the left side of the screen give access to ADISA's commands. The *Project* menu allows to create, open, duplicate or delete a design project. It also helps to manage the rights of access, allowing members of a team to work together on various elements of documentation and integrate their work. ADISA is the first instructional engineering system completely on the Internet allowing both online and off-line design specifications stored on either a server or a local disk drive. On and off-line copies are synchronized using the import feature in the Project menu.

The *Edit* menu offers different options to build the selected DE. One can save it and add to it user defined notes and tables of additional properties. DEs can be marked as completed or validated. A display of the DE can be shown and archived, allowing different versions to be saved for future production of reports.

The *Reports* menu allows to regroup the various versions of the DEs to create reports by phase, by axis, by author or any other criterion chosen by the designer. It helps create the report structure, order its various constituents and print the report.

The *Environment* menu offers a search function operating on the set of DEs (DHTML forms or MOT graphs), a complete on-line help system and some user options. It allows the download of the ADISA structure from the server to a client station for " off-line " work. It finally gives access to a navigation function, accessible through any Web browser, allowing a designer or an external observer to view and annotate the DEs to suggest improvements to the project team, without altering the initial documents

On the technical side, ADISA uses the basic features of Windows and Internet Explorer, especially dynamic HTML forms which modify themselves according to the user's choices. Once saved, DHTML forms, as well as MOT graphic models, are stored as XML files. This method allows the propagation of data between the DEs, an integrated search function for keywords in graphs and forms, as well as the communication with various types of databases and other systems such as authoring tools or learning management systems. The high graphic quality of the workbench provides a global and structured view of the learning objects facilitating the design process. The integration of tools in the workbench avoids the transfer of data, from one tool to another, thus saving time while preventing transcription errors or inconsistencies between related decisions.

4. Data propagation in the workbench

Data saved by the user from a DE form or a MOT model can be passed on to another DE in various ways Figure 4 shows the DHTML form of DE 224, allowing the designer to describe the properties for each of the learning units defined in a learning event network such as the one in Figure 3.

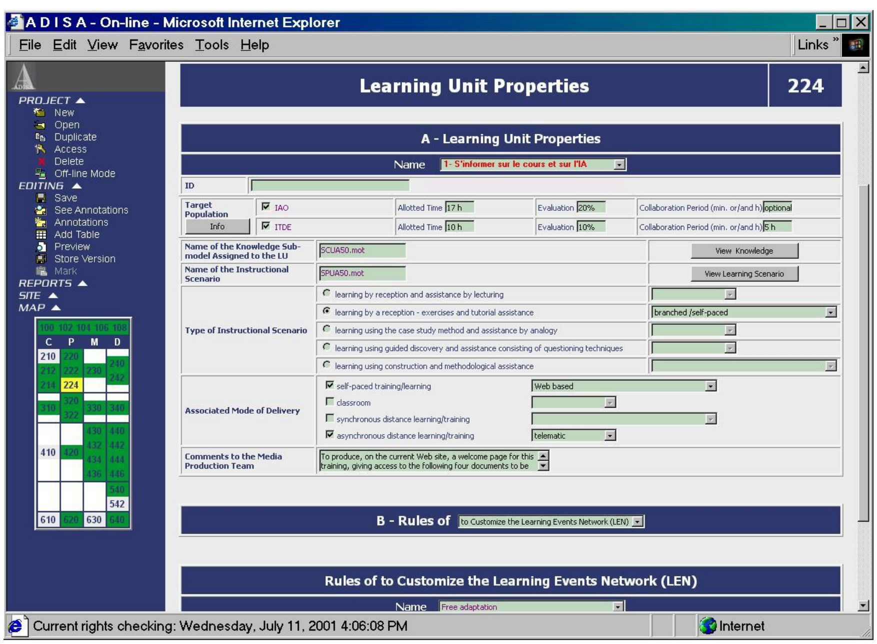

Figure 4– Example of data propagation to a DHTML form in ADISA

The first line on this DE 224 form holds the name of the learning unit. It is selected by the designer in a list of learning units read from the XML file saved from the graph constructed in DE 222. It is an example of automatic data propagation between two documentation elements and so are the lines describing target populations of a learning unit. This time, the XML file from DE 104 is read for the names of the target populations; here IAO and ITIE representing students registered in two programs.

Still on figure 4, we illustrate a non-automatic form of propagation. When the graph of the instructional scenario of a learning unit is built in DE 320, it can be displayed in a help window assisting the designer selecting, in DE 224, the type of scenario for this learning unit, for example, the type “tutorial with multiple choice” and “learner controlled pace”. This type of propagation helps the designer to check if the graph of the scenario corresponds to its description within DE 224.

ADISA tries to create a balance between automatic propagation of data and the user controlled propagation. Automatic propagation is convenient, because the user does not have to re-enter data already created in another DE. Without the automatic propagation, the use of the method would be too often tedious. On the other hand automatic propagation implies more difficult teamwork, because of the possible conflicts between two designers, one working to change data on which the other one bases himself to build another DE. This situation would then force designers to work in a sequential manner rather than in parallel, which might not be ideal.

Furthermore in many cases, automatic propagation is not desirable when one user is placed to make the best choices. For example, an important task of the design method consists in regrouping all the instruments appearing in the learning units, in a certain number of learning materials. The Content Expert is best placed to this task.

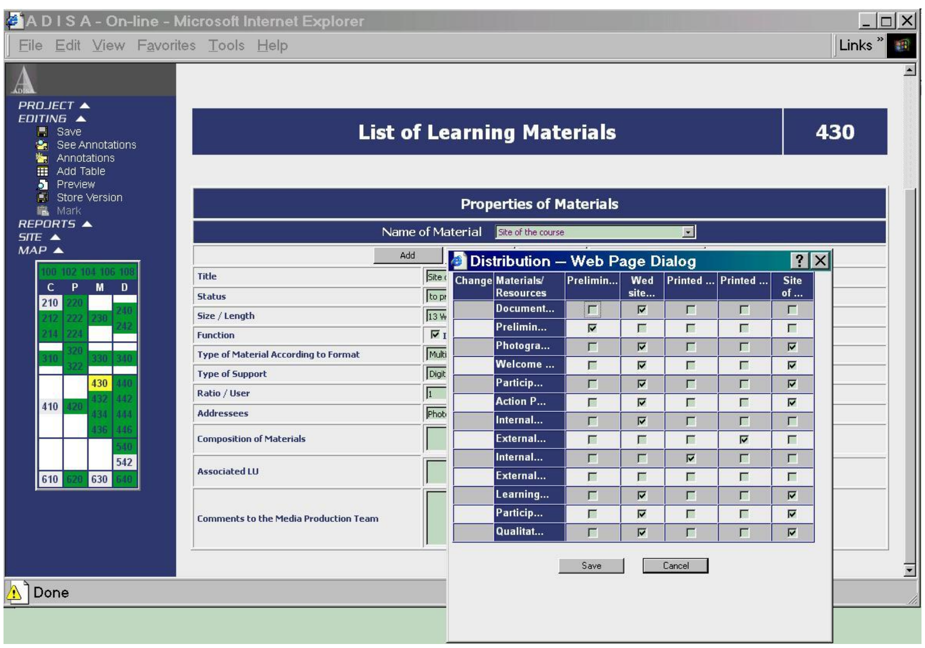

Figure 5 – Data propagation organized to support the designer’s decisions

To help the designer in this task, ADISA supplies a table illustrated on figure 5. Here, the system regroups instruments appearing in instructional scenarios (DE 320) and lists them as rows of the table. Columns represent the materials to be built, defined in DE 430. The interface on figure 5 allow the designer to decide which instruments will be regrouped and whether put on to one or several formats forming different types of material packages, just by checking the corresponding cells.

If another designer, working on a scenario in DE 320 decides to change the instruments serving as inputs to some of the activities, these changes will be announced to the designer in figure 5, so that s/he can interact with this colleague and complete the task while keeping the overall blueprint consistent.

Conclusion

In summary, ADISA is a sophisticated set of tools linked together to address, if needed, the full complexity of instructional engineering. In most cases, a team of designers will use only a part of the system but the interrelations between DEs is always made available in the integrated help system and by alerts when a task needs a previous one to be completed.

To keep the system as flexible as possible, while giving essential support to a team of designers, we have design three kinds of data propagation between instructional engineering tasks.

– *Automatic propagation* is done by the system without user intervention, information in a source DE is transmitted to a target DE to be displayed in some fields of its DHTML form.

– *Source propagation* consists in transmitting information from on or more sources in some DEs to a target DE where the user will select the information to be integrated in this DE.

– *Information propagation* simply displays information from a source DE that is particularly useful to build a target DE, the user remaining free to use this information or not.

ADISA is the first general instructional design support system solidly rooted in educational research, in knowledge engineering as well as software engineering principles. Further more, in all the 35 documentation elements (DE), the corresponding tools output learning objects description as XML files, thus providing an extensive set of meta-data that can be used for interoperability. This metadata is compliant with the ongoing efforts to create international standards such as IMS, IEEE, ARIADNE, AICC, SCORM or CANCORE.

Work is on-going at the LICEF research center and its associated company, Cogigraph Technology, to link ADISA to web based material production tools and delivery platforms for distance education. Meanwhile, the method and the tools are being applied in a number of projects and organizations for the design of e-learning environments.

Aknowledgement

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