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Learning Objects, Collaborative Learning Designs and Knowledge Representation

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1. LEARNING OBJECTS: MORE THAN JUST WEB PAGES

Developing high quality distance learning courses can be a difficult and expensive task. The reusability of educational resources becomes an important goal to re-inject quality objects and scenarios into new training contexts and prevent the costly “re-invent the wheel” syndrome. In the past few years, a vast movement towards international standards has been initiated up to the publication of the Learning Object Metadata (LOM) standard in 2002. A host of other standardized educational specifications have been published since then.

High quality learning objects are necessary but not sufficient to produce a high quality course or unit of learning. They need to be assembled into meaningful wholes. Figure 1 presents a view of the general educational modeling process that we propose. At the lower level, media elements are assembled to build documents and tools. At the second level, these learning

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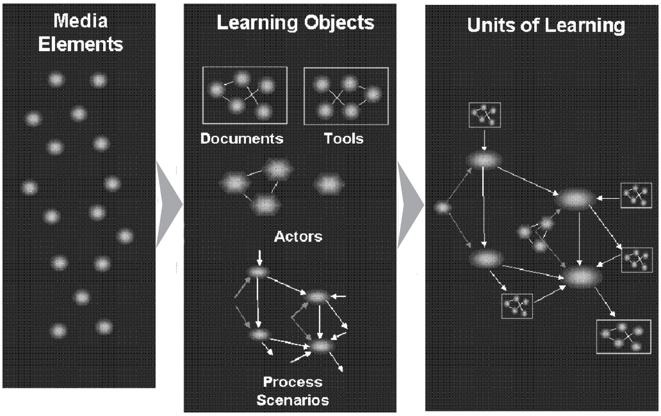

FIGURE 1
Educational modeling by reusing and aggregating learning objects.

objects can be aggregated to form larger documents and tools. Learning objects also include individual or group of actors that can be instantiated at run-time by actual persons providing information verbally or through emails, forum or chats. Individual operations or activities are also learning objects that can be grouped to form process-based learning scenarios. At the third level, units-of-learning are composed by re-using abstract scenario structures, adding the actors or roles ruling the operations and the documents and tools that serve as inputs to operations or that are produced as outcomes.

The definition of multi-actor process-based scenario is the goal of educational modeling languages (Koper 2001) such as the one provided by MISA (Paquette et al. 2005). The publication of the IMS Learning Design Specification (IMS 2003a), is the most important promising initiative to date, to integrate Instructional Design preoccupations into the international standards movement. It supports multiple learner and facilitator role, the definition of their collaboration, as well as the synchronization and personalisation of multi-actor learning scenarios.

The goal of the IMS-LD specification is "to provide a containment framework of elements that can describe any design of a teaching-learning process in a formal way" (IMS 2003). It bridges the gap between the design and the delivery of courses and learning units, by providing a standard XML schema as a result of applying an instructional engineering method like

MISA, and used to deliver training by a platform equipped with a compliant run-time engine. It thus supports the re-use and repurposing of units of learning and their components.

IMS-LD can be considered as an integrative layer to other specifications. It subsumes SCORM and other IMS specifications like content packaging (CP), simple sequencing (SS), learning object metadata (LOM), question and test interoperability (QT), reusable definition of competency and educational objectives (RDCEO) and learner information package (LIP).

Question/Comment: IMS appears essentially to be a high level specification language, which makes certain assumptions as to the nature of learning designs – e.g., communication between actors. I suspect it would have problems subsuming something like TutorIT, which is a general purpose tutoring/learning environment that can be configured to deliver learning in essentially any way desired, including learner controlled - see my AuthorIT article in latest issue of TICL and my Learning Object Highlights paper (attached). Also see my comment below.

2. COLLABORATIVE MULTI-ACTOR LEARNING DESIGNS

One of the most interesting features in IMS-LD is the possibility to synchronize actors in multi-actor process-based scenarios. From level A, to levels B and C, the specification adds more design capability for multi-actor scenario definitions for run-time support of the actors. The example on figure 2 presents an abstract level A scenario. Two actors are involved: actor A performs activities A1.1, A1.2….. and actor B performs B1.1 and B1.2.

A couple (actor role, activity) is called a role-part. In the level A specification, designers can use a limited vocabulary to control the flow of events, like the following one:

time limit; user choice

when—act-completed (start Act n);

completed-act; completed-activity;

completed-role-part

on completion -> feedback (web ou Imsld content)

On figure 2, activity A1.1 is completed after a time-limit, the other activities are completed by a user choice.

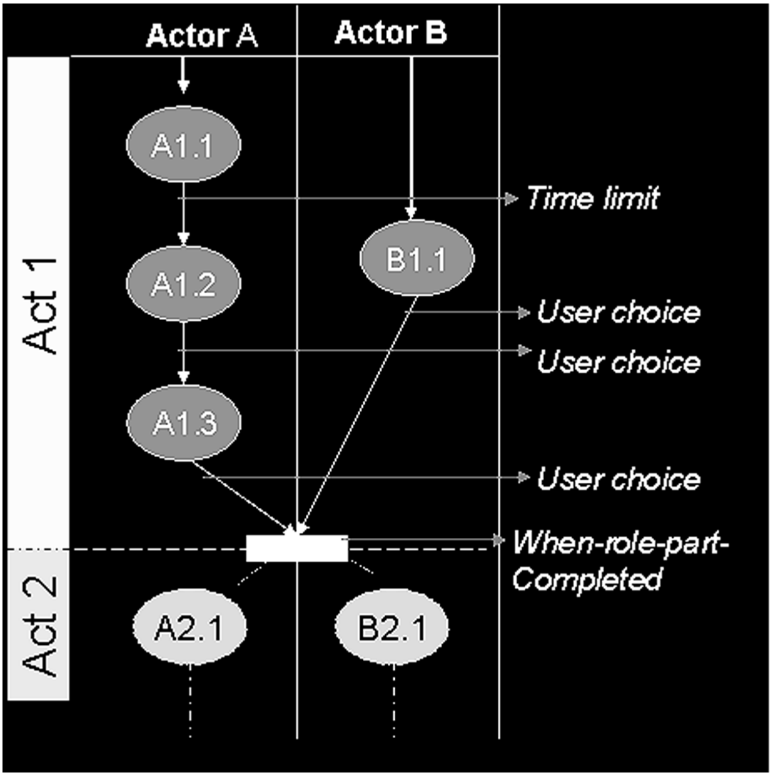

Figure 2 – Synchronisation in IMS-LD (level A)

When the two role-parts (actor A, activity A1.3) and (actor B, activity B1.1) are completed, a feedback can be given to users and act 2 can begin.

IMS-LD level B and C add more capacity to organize collaborative learning scenarios (or plays) through the use of properties, conditions (rules) and notifications between actor's roles. There are five types properties of a unit-of-learning described by attributes like name, type default value, reference and metadata:

Local personal properties
(related to a single user in a single run)

Local role properties
(related to a group of users playing a role in a single run)

Local properties
(related to the unit-of-learning for a single run)

Global personal properties
(related to a single user in all runs: portofolio property)

Global properties
(related to the unit-of-learning as a whole)

These properties are used to compose more complex statements to decide if an activity, an act or a play is completed in a unit-of-learning. Using more sophisticated rules based on the values of properties and combinations of property values, a designer can decide to change other properties, show or hide activities, suggest the use of resources, modify roles by notifying an actor, such as a facilitator that a change in sequencing of activities performed by other actors now requires a different activity to be performed by the facilitator. For example, on figure 2, if activity A1.2 is replaced by another activity, a notification can be send to actor B to change its activity B1.1.

The IMS-LD specification enables designers to define quite sophisticated collaborative unit-of-learning. (i.e., a high level specifications language – see above) One example is the Versailles unit-of-learning. The Versailles scenario organizes students into six groups, one for each of the six countries involved in negotiating the original Treaty of Versailles at the end of World War I. This Unit of Learning has three main phases:

A preparatory phase in which students are organized into six national negotiating teams through a computer-based forum giving access to the appropriate materials and a discussion group for each nation.

The negotiation itself, for which there is a main negotiation forum with a conference Chair, but there are also “side rooms” forums for each pair of countries to hold private discussions. When agreements are reached during negotiations, they are posted to everyone. Once the negotiations are completed, or after a given time has elapsed, participants are encouraged to review the outcomes of the day.

A post-negotiation period offers the students the opportunity to publish what they have learned in the form of web-based materials presenting national perceptions of what the treaty meant to each of the participating nations.

Such a complex scenario requires sound design and good computer support. Using the IMS-LD specification relieves the designer from taking care of all the technical details. This example shows very well the value of IMS-LD but still, we have found a few weaknesses where improvement should be made to the specification.

The representation for collaborative activities works well if the granularity of the interactions between actors is large, as in the Versailles scenario. If the granularity is smaller, as in educational games, then the representation in LD might become superficial (black box effect) or cumbersome if all small events need to be described.

Another difficulty is a certain form of ambiguity in the representation of collaborative activities. If N actors are involved in role-parts where they act in the same activity, there is yet no simple vocabulary within the specification to distinguish between the situations where they work separately, at different times, or together, at the same time.

Finally, there can be a great distance between pedagogical logic and technical requirements. IMS-LD has been built to facilitate run-time implementation. It is strongly influenced by the theatre play-act-scene metaphor. In a play, actors proceed sequentially through the acts, while acting in parallel within acts or scenes. This approach can be implemented in computers rather easily compared to situations such as project-based learning, where the flow of activities is not that sequential. There are many returns to previous activities or phases in the project; new activities or resources are added at run time and alternative activities or resources cannot be planned at design time. These more open learning scenarios are harder to manage even if the design embeds sophisticated control and support rules

3. LEARNING DESIGN AND KNOWLEDGE REPRESENTATION

As we have poinnoted in (Paquette and Rosca, (2004), a crucial area where IMS-LD needs to be improved is knowledge representation. Actually, the only way to describe the knowledge in the activities or in the resources is to assign optional educational objectives and prerequisites to the Unit of learning as a whole and/or to all or some of the learning and support activities. Objectives and prerequisites, although they correspond more or less to entry and target competencies, are unstructured pieces of text composed according to the IMS RDCEO specification (IMS 2002).

Unstructured texts are difficult to compare: consistency checking cannot be supported by a system between different levels of the LD structure, and even, at the same level, between the content of learning activities and resources, and the actors' competency. In fact, the knowledge in learning resources is not described at all, and the actor's knowledge and competencies are only indirectly defined by their participation in learning units or activities where educational objectives are associated. What we need is both a qualitative structural representation of knowledge in activities and resources, but also a quantitative one that can be provided by adding a metric to knowledge elements.

Without any good representation of the knowledge to be processed, a delivery system will be unable to help its users according to their present and expected state of knowledge and competency. To expand the capacity of such systems, the Explor@-2 delivery system (Paquette 2001) has been based from its inception on two structures, the instructional structure (corresponding to the learning design) and the knowledge/competency structure (corresponding to a domain ontology).

The association between learning objects (documents, tools, actors, activities) within a unit-of-learning, and the knowledge they contain or can act upon is a key concept for the semantic Web (Berner-Lee and al, 2001). Metadata describing learning objects and is not just a set of descriptive attributes. Metadata is linked to structured domain knowledge described as an ontology. For that purpose, our teams have developed recently two graphic editors within MOT+, one to describe standard learning designs in IMS-LD format, and the other to build ontologies to describe knowledge domains in standard OWL format (W3C, 2004).

We need a unique semantic referential for knowledge and competencies as proposed in the MISA method, for all the components of a Learning design, to reach what we can call a knowledge and competency equilibrium. For example, if a learning activity, to be achieved, requires a certain level of mastery of certain knowledge (a competence), then the resources provided to the learner (persons, documents and tools) must enable him to progress from a lower entry competence (knowledge + mastery level) to the target competency (or educational objective) proposed by the activity.

The knowledge domain can be structured in many ways: dictionaries, thesaurus, book summary, library catalog, indexes and metadata, knowledge graphs, ontologies, etc. The tree organization of the knowledge referential, instead of a more general graph format, seems an important property because it allows the default inheritance of a competency form a parent node to his children, unless these have been explicitly specified otherwise. This property can reduce significantly the burden of competency analysis and management. But the tree organization is toowo restrictive for describing the rich network of relations that ties the concept structures. A relational (predicate) logic must (not really –one of the major results/breakthroughs in AST representation of knowledge – see Scandura’s AuthorIT, 2005 and

Structural Analysis, 2003, articles in TICL – is that ANY idea or process can be refined arbitrarily (hierarchically). Relations are not essential in knowledge representation precisely because ANY relation can be represented as a function/process) then complete the concept tree and sustain more refined mechanism of conceptual matching. This is exactly what ontology engineering provides (Davies et al 2003, Breuker et al 1999).

But if we use only domain ontologies without defining mastery levels, we obtain a coarse granulation of sense and, as a consequence, weak semantic management capabilities, both by human facilitators or computer support systems. The evolution of a learner on a competence scale materializes an important aspect of the learning process: therefore, it must be managed explicitly and expressively

We thus need measures of knowledge mastery, a weighted ability defined on that knowledge. We can use different mastering scales: simple quantitative percentage, levels in Bloom taxonomy, combinations between generic skills taxonomies and performance levels, etc. The description of knowledge mastery must be reasonably simple, to be manageable. Still, the levels must correspond to clearly identify cognitive processes such as applying, synthesizing or evaluating knowledge. This is what the generic skill's taxonomy embedded in MISA provides (Paquette 1999).

Combining the preceding requirements suggests that a good candidate for the semantic indexing of educational resources, actors and activities will be a combination between domain ontologies and a simple and expressive competency ontology.

CONCLUSION

The IMS-LD specification based on Educational modeling languages is a great progress in international standards and extensions like we the ones we have proposed for knowledge and competency referencing or for collaborative activities car be added. In our research team (CICE[1]) we are completing the integration of IMS-LD and OWL into the MISA/MOT+ framework. In the five-year term of the LORNET[2] project, we will be working to extend the IMS-LD to a more general learnflow model and to adapt our Explor@2 delivery system to fully exploit the multi-actor concept

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[1] CICE is a Research Chair on Instruction and Cognitive Engineering, hosted by LICEF-CIRTA.
[2] LORNET is a Canadian Research Network led by the first author; www.lornet.org.

proposed by IMS-LD specification. On a larger scale, we believe that international standardization efforts should focus on the very important question of the integration of knowledge and competencies into educational modeling languages. In a Semantic Web perspective, this is an essential task where strong international collaboration is needed. (Gilbert, the importance of knowledge representation in this regard is very important as you indicate. However, I would argue that the issue is largely one of science not collaborative consensus. That doesn't mean that one cannot use relationships as above; only that if they are used, instead of hierarchical AST-type hierarchies as defined in the articles referenced above, then separate instructional strategies will have to be developed de novo for each new body of content. This is no loss at present since this is what we do now. However, it is now clear that AST representations make it possible to devise general purpose tutors that operate on the basis of content structure alone (without attention to its semantics).

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