Contributions to Educational Modelling Languages

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Abstract. Educational Modelling Languages (EMLs) have been proposed to enable the modelling of instructional resources in accordance with different learning approaches. An EML provides a containment framework of elements that can describe any design of a teaching-learning experience in a formal way. This thesis tries to contribute to the development of EMLs focusing on collaborative learning scenarios and considering constructivist and social learning models. We have observed that some collaborative learning practices cannot be adequately modelled using available EMLs. The first labour involves the rigorous demonstration of this assumption. In this way, a benchmark to evaluate EMLs’ expressiveness and suitability in collaborative settings is proposed. This benchmark will enable to measure the capacity of an EML to model collaborative learning practices. Then, we plan to propose a new EML or extensions over the IMS Learning Design proposal (currently the EML standard) in order to truly support the modelling of instructional resources for collaborative learning practices.

1 Introduction

The purpose of Educational Modelling Languages (EMLs) [1] is to support the modelling of diverse teaching-learning experiences (instructional resources), embodying different pedagogical approaches and in different contexts. It is claimed that IMS Learning Design (LD) [2], proposed as the EML standard, can formally describe any teaching-learning scenario for a wide range of pedagogical approaches. However, we consider that LD provides insufficient support to model collaborative learning practices.

The first purpose of this work is to demonstrate this claim. We propose the development of an evaluation benchmark to provide measures of how well a particular EML enables the modelling of instructional resources to support the development of collaborative learning experiences. The second goal is to provide an enhanced EML that enables the truly modelling of such instructional resources involving collaborative issues.

1 IMS Global Consortium, currently, one of the most active e-learning standardization bodies.
http://www.imsglobal.com
2 Learning Objects and Educational Modelling Languages

During the last years, several standards have been proposed to improve reusability and interoperability of digital instructional resources. The first initiatives were devoted to the definition of a conceptual reusable building block, namely the Learning Object (LO). The main points in the LO proposal are [3]: (i) to facilitate the search and location of appropriate digital contents; (ii) to enable the transfer of digital contents between systems; (iii) to enable the composition of new contents through the aggregation of existing ones; etc. The eventual purpose of this initiative is to promote the development of a huge amount of LOs and create an economic with vendors offering high quality LOs to final e-learning institutions, authors, learners, etc.

Nevertheless, a problem remains in the sense that LOs are agnostic in relation with pedagogical approaches. LO initiatives do not involve any concerns related to the type of pedagogy followed. Really, they use an implicit specific pedagogical approach based on content delivery. But, many times other pedagogical approaches have to be used in order to provide better learning results [4]. The first standardization proposals in this area also used an implicit instructional design idea based on content delivery. These models were based in the definition of goals, potential resources (e.g. texts, figures, and tools), sequence of topics and how to assess the learners. But, this rather traditional model of education is rapidly changing. Today there is a broad range of new pedagogical approaches that promotes a shift on the way to describe educational contents, often based on constructivist and social principles that are developed in collaborative scenarios [4].

These different instructional and pedagogical approaches need to be supported in the modelling of instructional resources in accordance with appropriate standards to promote their reusability and interoperability. EMLs were proposed as standard languages to support such modelling. Accordingly to the EML review [5] performed by the CEN/ISSS WS-LT2 “An EML is a semantic information model and binding, describing the content and process within a ‘unit of learning’ from a pedagogical perspective in order to support reuse and interoperability”. The IMS LD proposal is a meta-language that allows to codify units-of-learning (e.g. courses, course components, programs of study), associating each element of content (e.g. texts, tasks, tests, assignments) with information describing its instructional strategy (e.g., roles, relations, interactions, and activities of students and teachers). It is important to note that EMLs are not concerned with educational or technological issues, but with the coordination of the elements involved in educational practices.

In collaborative learning settings, EMLs are related with Computer-Supported Collaborative Learning (CSCL) Scripts [6]: “A script is a story or scenario that the students and tutors have to play as actors play a movie script”. These scripts are proposed as activity programs that aim to facilitate collaborative learning by specifying activities in collaborative settings, eventually sequencing these activities and assigning them to learners. Anyway, currently there is no language or EML proposal that completely satisfies the design requirements involved in CSCL Scripts.

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3 Towards Evaluation Benchmark for EMLs

Our first task is focused on achieving an evaluation benchmark for EMLs. We try to find a set of criterions that can provide a measure of the level of expressiveness and suitability of EMLs to model collaborative practices, mainly. In order to achieve this evaluation benchmark we have followed a perspective and pattern-based approach that has been already used to evaluate workflow languages and systems [7]:

1. The first stage of the approach concerns the identification of perspectives to enable the separation of concerns. A perspective is considered as a feature that involves a certain purpose and that can be analyzed independently. In the workflow literature a perspective is defined as a set of elements that target some sub-set of self-contained functionality. Some of the perspectives are: activity sequencing [8], data flow [9], resources, operations, etc.

2. The second stage is devoted to the identification of patterns to obtain a set of requirements that must be satisfied in each perspective. A pattern is an abstraction that is frequently repeated in a design domain, and can be considered as a general solution to a common problem [10]. We identify patterns in each perspective as the common forms involved in the modelling of educational practices. In this way, patterns are used to describe EML requirements capturing the essence of the problem in a certain modelling perspective. The design patterns provide independence from the EML used and at the same time independence from the essential requirements of the domain that they attempt to address.

The first perspectives that can be identified in educational processes are provided by the answers to the questions who?, what?, and When?: (i) organizational perspective (who are the participants (learners and staff) involved in the process? What roles do they play? How are they organized?); (ii) functional perspective (what is that the participants do? Do they create documents? Do they transfer information to other participants); (iii) behavioural perspective (how do participants know when to start? When is the activity finished?). Each perspective is concerned with a concrete feature of educational processes. Following this approach we have identified eleven perspectives. Six of them have been directly taken from the workflow domain: functional, behavioural, informational, operational, organisational, and resource. In addition, five more perspectives have been considered to support collaborative and educational process modelling: causal, temporal, authorisation, interaction, and awareness.

Currently we are identifying patterns and describing them in each of the previous perspectives. These patterns made up the basic features in the identified perspectives and provide the basics for evaluating LD. The collected patterns have been derived and extrapolated from insights into real-cases, use cases gathered by workflow standardization initiatives, generic scenarios identified in e-learning standards, and case studies reported in the literature. It is not claimed that the proposed set of patterns is complete. The aim is simply to consolidate recurrent scenarios and abstract them in a way independent of the technology and educational approach.
4 Perspectives

Perspectives have being identified using Activity Theory as reference framework, see figure 1. According to Activity Theory [11,12], an activity is a way of action of a person, or group of persons, addressed to an object in order to achieve a certain goal (in general the terms activity and task are used interchangeably, but we prefer to use task. As Alain Wisner distinguished: “Tasks are what managers set - they are the prescribed work. Activity is what people actually do”). The Activity Theory Expanded Mediation Model [13] incorporates the Community, Rules and Division of Labour to the basic Role, Environment and Object elements. The Community puts the emphasis in the social context where the subject operates. The Rules component highlights the fact that within a Community, Subjects are bound to rules and regulations that affect the way the Task is carried out. The Division of Labour refers to the allocation of responsibilities to the Subjects.

![Figure 1: Learning entities and perspectives in accordance with the Activity Theory](image)

In accordance with this schema, the perspectives considered are:

- **Functional.** It answers the question about what has to be done in each task. The functional perspective characterizes the tasks that have to be performed and how such tasks are decomposed into smaller units (sub-tasks).
- **Resource.** It answers the question about who is responsible of performing each task. This perspective is concerned with the management of Agents and their assignment to tasks.
- **Informational.** It answers the question about what information is available to perform a task. It involves the artefacts (e.g. properties, documents, etc.) available in the environment and the flows of information between tasks and artefacts.
• **Operational.** It answers the question about what operations are available to perform a task. It comprises the applications used in the tasks and the issues required to ensure interoperability.

• **Process.** It answers the question about when to perform a task. This perspective (also named as process or control flow) describes the execution ordering of tasks. It is possible to distinguish between rigid ordering of tasks and free-navigation models.

• **Temporal.** It is concerned with the temporal conditions that determine when a task can be performed. It adds another dimension to the control flow of tasks. Without temporal constraints, a task is initiated when its preceding tasks have finished.

• **Organizational.** It answers the question about what organizational structure is involved. The organizational perspective describes the relationships on the Community and the members of groups.

• **Authorisation.** It answers the question about what access rights have users to access objects and operations. It controls the access of users to the elements contained in environments, modelled in the informational and operational perspectives.

• **Interaction.** It answers the question about how participants can interact among them during collaboration, communication and co-operation. These functionalities are provided by applications and services modelled in accordance with the operational perspective. This perspective involve issues to manage and control the applications use, such as: session control, membership control, floor control, conversation management, version control, time-stamp control, etc.

• **Awareness.** It answers the question about what runtime information have to be presented to each participant. Awareness refers to how is made ‘visible’ or ‘available’ to participants what the other participants are doing or have done.

5 Patterns

In this section we present a brief description of some group of patterns already identified. Their purpose is to describe modelling use cases that should be supported by EMLs in each perspective. Table 1 lists some of the patterns grouped by categories in each perspective.

5.1 Functional Patterns

The following two points can be taken as guidelines for the definition of patterns in this perspective:

- Composition patterns distinguish whether the definition of sub-processes is possible, whether defined processes can be reused in later definitions of other processes, and if the breakdown of goals into sub-goals can be performed in a successive way. This last point is not adequately satisfied in LD,
because it would require the combination of several units of learning. The current LD specification does not solve how to connect several units of learning completely.

- Constraint patterns are concerned with the description of pre-conditions, post-conditions, and interdependencies for the achievement of goals. It is possible to consider positive and negative relationships: two goals conflict if they cannot be achieved together.

### Table 1: Perspectives and patterns for group-based educational design

<table>
<thead>
<tr>
<th>Perspective</th>
<th>Pattern Groups: Patterns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Causal</td>
<td>Educational Info: Educational Goals, Pre-requirements, etc.</td>
</tr>
<tr>
<td></td>
<td>Learner Info: Preferences, Background, etc.</td>
</tr>
<tr>
<td>Functional</td>
<td>Composition: collaborative, cooperative, collective, etc.</td>
</tr>
<tr>
<td></td>
<td>Constraint: pre/post-conditions, inter-dependencies, etc.</td>
</tr>
<tr>
<td>Behavioral</td>
<td>Basic Control: Sequence, Parallel Split, Synchronization, etc.</td>
</tr>
<tr>
<td></td>
<td>Advanced Branching and Synchronization: Multi-choice, etc.</td>
</tr>
<tr>
<td></td>
<td>Structural: Arbitrary Cycles, Implicit Termination, etc.</td>
</tr>
<tr>
<td></td>
<td>Involving Multiple Instances: Without Synchronization, etc.</td>
</tr>
<tr>
<td></td>
<td>State-based: Deferred Choice, Milestone, etc.</td>
</tr>
<tr>
<td></td>
<td>Cancellation: Cancel Activity, Cancel Case, etc.</td>
</tr>
<tr>
<td>Temporal</td>
<td>Synchronization: A before B, A starts B, A finishes B, etc.</td>
</tr>
<tr>
<td></td>
<td>Scheduling: Deadline, Start Point, etc.</td>
</tr>
<tr>
<td></td>
<td>Allocation: Maximum, Minimum, Average Execution Time, etc.</td>
</tr>
<tr>
<td>Informational</td>
<td>Data visibility: Task Data, Block Data, Scope Data, etc.</td>
</tr>
<tr>
<td></td>
<td>Data interaction: Task to Task, to Multiple Instance Task, etc.</td>
</tr>
<tr>
<td></td>
<td>Data transfer: by Value, by Reference, Copy, etc.</td>
</tr>
<tr>
<td>Operational</td>
<td>Tool location: Fixed, Capability Description etc.</td>
</tr>
<tr>
<td></td>
<td>Tool interaction: Request, Request-Response, Solicit-Response, etc.</td>
</tr>
<tr>
<td>Authorization</td>
<td>Static (Access Control) Authorization, Obligation, etc.</td>
</tr>
<tr>
<td></td>
<td>Dynamic: Delegate, Revoke, Cancel, Request, etc.</td>
</tr>
<tr>
<td>Interaction</td>
<td>Session Management: Automatic, Human Controlled, etc.</td>
</tr>
<tr>
<td></td>
<td>Membership Management: Guest List, Denied List, etc.</td>
</tr>
<tr>
<td></td>
<td>Floor Control Management: Free, Moderated, Circular, etc.</td>
</tr>
<tr>
<td></td>
<td>Conversation Management: Structured Conversation, etc.</td>
</tr>
<tr>
<td></td>
<td>Version Control Management: Operation, Participant-based, etc.</td>
</tr>
<tr>
<td></td>
<td>Time Stamp Management: Periodic, Operation-based, etc.</td>
</tr>
<tr>
<td>Organizational</td>
<td>Participant grouping: Flat, Hierarchical, Constrained, etc.</td>
</tr>
<tr>
<td></td>
<td>Participant relationships: Delegation, Priority, etc.</td>
</tr>
<tr>
<td>Resource</td>
<td>Resource Assignment: Single Offer, Multiple Offer, Allocation, etc.</td>
</tr>
<tr>
<td></td>
<td>Resource Properties: Runtime Data, Portfolio, etc.</td>
</tr>
<tr>
<td>Awareness</td>
<td>Asynchronous: Filtered, Aggregation, Summary, History, etc.</td>
</tr>
<tr>
<td></td>
<td>Synchronous: Tele-pointer, Presence Indicator, etc.</td>
</tr>
</tbody>
</table>
5.2 Temporal Patterns

The identification of patterns in this perspective was carried out taken into account the works of [14] and [15], about temporal interdependencies in Computer-Supported Cooperative Work (CSCW). Bardram identifies three types of temporal issues that we follow to propose the corresponding patterns:

- **Synchronisation patterns** are focused on ensuring that activity “a” by person “i” occurs in a certain relation to the time when activity “b” is done by person “j” according to the conditions of the collaboration. For example, consider a learner carrying out a simulation in a dangerous environment that should be supervised by a tutor. It should be required that both tasks, learner simulating and tutor supervising, be realised exactly at the same time. We have identified the following patterns for collaborative interaction: (i) A equals B; (ii) A starts B; (ii) A finishes B; (iv) A overlaps B; and (v) A during B.

- **Scheduling patterns** are basically related with the creation of temporal plans by setting up temporal conditions for when some event will occur or some product will be available. For example: deadline, start point, etc. These patterns are directly related with the management of agendas and timetables.

- **Allocation patterns** are concerned with the decision of how much time is devoted to various tasks. Minimum, maximum, and average execution times for each task are patterns in this group.

Current LD elements are not able to express most of the patterns defined in this category. Only some of the allocation patterns are supported. For example, it is possible to assign a deadline to activities. Nevertheless, it is not possible to solve any of the synchronization patterns, for example the initiation of the execution of A enables the execution of B (A starts B).

5.3 Resource Patterns

One important issue in the resource perspective is the manner in which tasks are advertised and assigned to specific human resources (learners and academic staff) for execution. There are different ways in which a task may be assigned to a resource [16]:

- A task may be offered to a single resource meaning that the system informs exactly one resource about its availability. Random Allocation is a special pattern of this group where a participant is selected on a random basis.

- A task may be offered to multiple resources, where the system informs multiple resources of its existence.

- The system may pre-emptively assign the task to a resource. Patterns in this group include: Direct Allocation, Role-based Allocation, Separation of Du-
ties (this involves the ability to specify that two tasks must be assigned to different participants), etc.

LD uses a pre-emptive assignation mechanism without variants. There are many patterns in this perspective that cannot be expressed by the current elements of the specification. For example, the idea of offering a task to several participants that has to be performed by a volunteer has not been taken into account and it is very used in traditional classrooms.

6 Conclusions

We consider that the EML approach to describe and support diverse learning models is going to play a main role in the future development of e-learning systems. The IMS LD proposal is considered as the EML standard. It integrates and uses other e-learning standards: metadata, content packaging, questionnaires, etc. In this way, it acts as a core specification that tries to support the modelling of instructional resources in accordance with different pedagogical approaches. Our purpose is to contribute to the development of EMLs, enhancing the support of such different learning approaches in collaborative settings. We have presented an evaluation benchmark to assess the modelling capacity of EMLs. It is not based on educational or technological issues, but, as EMLs, it is concerned with the coordination issues that have to be considered in order to enable the description of collaborative educational practices. After this work we plan to propose some extensions to LD.

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References


