*Journal of Universal Computer Science, vol. 11, no. 9 (2005), 1458-1469*
*submitted: 15/2/05, accepted: 30/6/05, appeared: 28/9/05* 

# From Contents to Activities: Modelling Units of Learning

**Manuel Caeiro-Rodríguez**
(University of Vigo, Spain
Manuel.Caeiro@det.uvigo.es)

**Martín Llamas-Nistal**
(University of Vigo, Spain
Martin.Llamas@det.uvigo.es)

**Luis Anido-Rifón**
(University of Vigo, Spain
Luis.Anido@det.uvigo.es)

**Abstract:** This paper discusses the modelling of a *Unit-of-Learning* (UoL) (e.g. a lesson, a course) in e-learning. So far, the modelling of UoLs has been heavily focused on the definition and organization of contents. Currently, social and constructivist pedagogical approaches are demanding that learners get involved in more actual activities (e.g. solving problems, pair-work, group work). *Educational Modelling Languages* (EMLs) have been proposed to support the modelling of such activity-based UoLs. In this way, EMLs enable the definition of learning environments, goals, participants, etc. Nevertheless, the elements provided by current EMLs are not sufficient to model certain learning activities, mainly those involved in active and collaborative learning scenarios. In this paper we identify a set of perspectives and patterns that should be considered in an EML to support the design of collaborative UoLs.

**Keywords:** E-learning, Collaborative Learning, Educational Modelling Language, Unit of Learning, Learning Object
**Categories:** K.3.1, K.3.2, H.1

## 1 From Contents to Activities

In the past, when teachers had to design a *Unit-of-Learning* (UoL) (e.g. a lesson, a course) they used an implicit educational design idea based on knowledge transmission [Koper, 03a]. They thought about content, potential resources (e.g. texts, figures, and tools), the sequence of topics and how to assess the learners. The teacher designed learning experiences (or more precisely, education) within the context of a specific environment: the classroom. When using a web-based environment, they would follow the same design process: decide on content, resources, the sequence of topics and assessment of learners within the constraints of the new e-learning environment.

But this rather traditional view of education is rapidly changing. Today more emphasis is placed upon the design of *learning activities*, instead of the content to be transferred. There is a broad range of new pedagogical approaches that promote this shift often based on constructivist and social principles [Strijbos, 04]. Examples include *collaborative learning*, where discussion plays an important role; *problem-*

*based learning,* where knowledge is constructed by learners solving real problems in actual situations; *inquiry-based learning,* focused on questioning, problem-solving, and critical thinking; etc. The key to these pedagogical approaches is to make learners active by providing them with a broad range of tasks, problems and prompts (referred to as *learning activities*) in order to stimulate the process of learning.

This shift from contents to activities is also present in some recent proposals devoted to the application of pedagogical and instructional principles into the design of e-learning experiences. We present some proposals that focus on the features of *learning activities*:

- In a review about e-learning models [Beetham, 02], the authors propose a two-level design approach based on *theoretical learning* models. At the higher level of planning, a teacher is concerned with the overall approach and at the lower level with specific *learning activities*. The mapping of theoretical into practical models involves the specification of the flows of *learning activities*.
- In *Computer-Supported Collaborative Learning* (CSCL), the concept of *script* [Dillenbourg, 02] is proposed as a way to structure the collaborative process in order to benefit the emergence of productive learning interactions. A *CSCL script* is used as a *story* that learners and tutors have to *play*. Like actors playing a movie script, learners and tutors perform a certain flow of *learning activities*.
- The work on *Educational Modelling Languages* (EMLs) [Koper, 01] is the most important initiative so far to integrate *instructional design* principles into the process of learning standardization [Paquette, 03]. As Koper says: "*A lot of learning does not come from knowledge resources at all, but stems from the activities of learners solving problems, interacting with real devices, in their social and work situation*." The shift towards the specification of *learning activities* is proposed as a central part of the EML proposal. The EML proposes a way to represent UoLs.

Therefore, the design of UoLs requires the modelling of *learning activities*. An EML is based on a corresponding meta-model to enable such modelling (it is referred to as meta-model because it is a model designed to create models, namely UoLs). The meta-model defines a set of elements and establishes relationships among them to enable an eventual computational support for the UoL. In this way, educational designers can create UoLs that may be supported by appropriate execution engines.

This paper analyzes the features that should be included in an EML meta-model and considers its relationship with the *Learning Object* (LO) concept. Currently, the focus on content promotes a standardization effort in the e-learning domain to obtain reusable and interoperable learning building blocks in the form of LOs. At the present time, the focus on *learning activities* requires a similar effort to define reusable and interoperable blocks based on activities, namely UoLs.

In the next section we present how this shift from contents to activities is being applied to Learning Technology (LT) standardization, transferring the attention from LOs to UoLs. Then, in section 3, we identify the main issues that should be included in an EML meta-model. The paper finishes with a few conclusions.

## 2 From Learning Objects to Units of Learning

There has been a shift from contents to activities in the design of learning experiences. Likewise, the LT standardization process is witnessing a shift from LOs to UoLs as the basic reuse unit. In any case, the UoL concept requires the same properties of *reusability* and *interoperability* considered previously for LOs. In this section, we analyze the principles involved around LOs and the new ideas about UoLs.

The main focus on learning standardization has been on developing specifications for LOs. A standard for LOs metadata exists [Duval, 02] and there substantial interest in LOs packaging with a view to facilitate reusability and interoperability. The IEEE *Learning Object Metadata* (LOM) Standard defines a LO as: "*any entity, digital or non-digital, that can be used, reused, or referenced during technology-supported learning*". This definition covers a wide spectrum of entities, enabling a great variety of Los to be considered. However, it is so general and open that it has very few practical uses [Koper, 03a]. The LO abstraction does not provide any structure or description of the instructional use of the resources provided. In this way, the support that can be provided by a computational system is very limited. For example, a brainstorm session can not be appropriately specified as a LO, because the interactions that could be coordinated during the learning process (e.g. floor control) are not described according to a well-established structure.

The UoL concept was introduced by the *IMS Learning Design* (IMS-LD) [Koper, 03b] specification, the most outstanding EML proposal, as the basic reusable building block for the design of learning experiences. The central point of a UoL is the *task* or *activity*, conceived as one or more *actors* (e.g. teachers, learners) working towards a certain *learning goal* in a given *environment*. The relationship between UoLs and LOs may be established through the *environment* element. The *environment* contains the required resources and services, also including LOs, needed to perform the proposed *task*. This is the basic principle behind EMLs and IMS-LD; they differentiate between activities and environments. People learn by doing (by performing *learning activities*) within an environment, composed by a set of LOs, which enables and/or supports them. The concept of LO is not lost, but integrated into the new concept of UoL, where it plays a secondary role.

In this way, the concept of UoL is proposed as the new unit of reuse for the design of e-learning experiences. A UoL in IMS-LD presents a structure with an explicit semantic and pragmatic meaning. Therefore, a UoL cannot be broken down into its component parts without losing its effectiveness towards the successful completion of the learning objectives. However, a UoL is a reusable component, and it can contain other UoLs or be integrated into units of several types and sizes: courses, lessons, etc. In addition to the learning goals, a UoL is complemented with meta-data and learning pre-requisites that facilitate its reuse in different contexts.

Nevertheless, the present definition of UoL as it is presented in current EMLs does not gather all the possible behaviors and interactions that may be computationally supported during a *learning activity*. There are situations related to human-computer interaction and human collaboration that are not adequately modelled. In the next section we analyze the current elements included in the description of the UoL and identify what issues should be considered.

## 3 Towards a Meta-model for Modelling Units of Learning

We consider a meta-model as a set of elements and relationships that are used to model UoLs. In this section, we focus our attention on the set of issues, referred to as perspectives, which should be considered in such a meta-model to support the design of collaborative learning experiences. This is not intended to be an exhaustive analysis but does hope to capture as many issues as possible.

### 3.1 An UoL According to Current EMLs

According to current EMLs, mainly IMS-LD [Koper, 03b], a UoL is a *method* that proposes that *participants* (learners and teachers) attain learning *goals* by performing *activities* in a certain order in the context of an *environment*. The main elements involved in these specifications are:

1. The *activities* that represent particular tasks to be attained in order to achieve certain goals. Each *activity* is associated with an *environment* where it has to be carried out and with a certain *role* that is assigned to it. Usually, an UoL is composed of a set of *activities* that have to be performed according to a well-established scheme. IMS-LD considers a theatrical metaphor and the following concepts to support the activity sequencing:
   - A *role-part* enables a *role* to be assigned to an *activity*. In this way it is possible to describe the activities to be performed by each participant.
   - The *act* concept is used to group several *role-parts*. The *role-parts* defined in the same *act* may be performed concurrently and have to end at the same moment.
   - A *play* is used to sequence *acts* in time. Each *act* has to be performed just after the previous *act* and before the next one.
   - The *method* is the upper level concept used to arrange the different *plays*. A *method* may be made up by several *plays* that may be performed concurrently.
   - *Properties* are needed to store information about a student's progression or specific information (e.g. learning style, preferences).
   - *Conditions* use *properties* to express rules to adapt to specific circumstances or preferences (e.g. students' prior knowledge). They are used for personalization and customization.
   - *Notifications* are mechanisms to trigger new activities based on an event during the learning process. For instance: the teacher may be notified to provide assistance when a particular question is posed by a student.
2. *Roles* are used to specify the type of participants that will be involved in performing the tasks. There are two basic roles: learner and staff; but these can be further defined to allow more specific sub-roles. Groups may be defined but in a constrained way (e.g. it is not easy to describe the components of groups, to assign participants to groups dynamically during runtime, etc.).

3. The *environment* is composed by learning resources and services. Resources may be defined at design time as LOs. Learning services, such as chat, e-mail, monitoring, discussion forums, etc., are used for communication and functional purposes (e.g. a simulator, a shared editor). Some of these services consider particular roles that have access to special operations in the service (e.g. the conference service enables the definition of a moderator role, which controls the participation of the other participants).
4. *Goals* represent learning objectives to be achieved by participants. These are *learning goals* that establish the eventual knowledge, skills or attitudes that the UoL is intended to provide to the learners involved. These *learning goals* should not be confused with the goals of the tasks proposed to the participants in the UoL (e.g. the learning goal is to gain certain knowledge, and the task involves reading a document and writing a resume). In addition, prerequisites may be specified to establish the conditions required to be attempted by the UoLs. Furthermore, meta-data is included to enable and facilitate reuse.

Using these elements, the proposed meta-model supports the modelling of learning experiences involving several perspectives. In the next section these are described and we identify other perspectives not supported by the current IMS-LD specification, but that should be considered in the design of learning experiences.

### 3.2 Perspectives in the Modelling of Learning Experiences

In this section we identify a set of perspectives that should be considered in the modelling of learning experiences, paying special attention to collaborative scenarios. We plan to characterize interactions and behaviors involved in learning situations in a way that they can be computationally supported. The purpose of identifying these perspectives is to provide a clear separation of concerns in the development of an eventual EML meta-model. The focus on collaborative learning is adopted because it involves a rich set of perspectives.

In order to identify the perspectives, we have studied different works in the e-learning, CSCL, and *Computer Supported Collaborative Work* (CSCW) domains [Strijbos, 04] [Aalsts, 03b] [Pinelle, 03] [Dillenbourg, 02] [Guareis, 00], [Ellis, 99]. In [Strijbos, 04] the authors consider five main principles involved in the design of group-based learning. Perspectives for workflow systems are described in [Aalsts, 03b] for CSCW in [Ellis, 99], and for human-computer interaction analysis in [Pinelle,03]. In [Guareis, 00] five meta-models for CSCW design (Coordination Theory, Activity Theory, Task Manager, Action/Interaction Theory, OOActSM) are analyzed identifying many similarities and differences between them. None of the analyzed meta-models seemed to be general and complete enough, so they proposed a new meta-model to exploit the similarities encountered in the analysis.

After studying these and other works, we believe that for a meta-model to support the design of collaborative learning experiences it should be arranged around a *task* structure. In the *task*, participants work like actors in *roles* towards the achievement of certain *goals* in appropriate *environments* composed of resources (Figure 1). Our *task* proposal can be split into several sub-tasks, each one of which is involved in the three main elements: *roles*, *goals*, and *environment*. Considering the relationships among *roles*, *goals*, and *environments* intended perspectives can be identified.

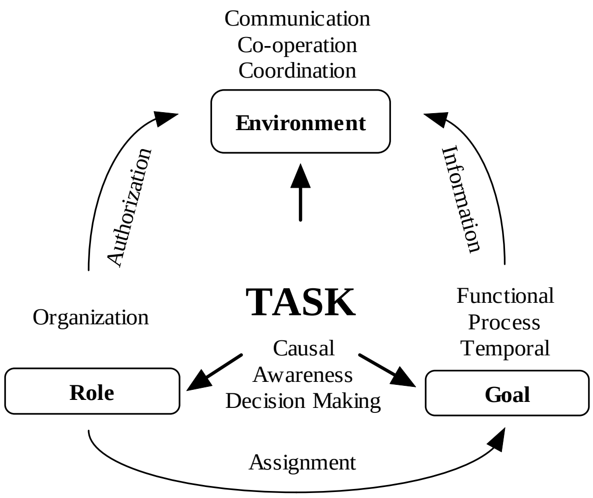


*Figure 1: Elements and perspectives considered in learning modelling*

#### 3.2.1 Goal

The *goal* is the objective that drives the efforts of the *role* or *roles* in the development of the *task*. This group of perspectives is related to the *activity* concept introduced in section 3.1. We consider that a *goal* can be indivisible, a single *goal* (atomic task), or it may be split into several sub-*goals* (composed task). In the latter case the specification of the *task* may also be split into several sub-*tasks* to achieve each of the sub-*goals*. Therefore, we consider the following perspectives related to *goals* and sub-*goals*:

- The *functional* perspective is concerned with atomic and composite *goals*, and as a consequence with atomic and composite *tasks*. Composite *goals* should be supported to any degree of division. This simple requirement is not completely supported by IMS-LD because it is possible to include a UoL as part of another UoL, but the correspondence between the elements of a parent UoL (e.g. *roles*, *environments*) and the elements of a child UoL is not specified.
- The *process* perspective (or *control flow*) is devoted to describing the order in which different *goals* and corresponding tasks should be attained. Usually, EMLs support some of the more common types of ordering, but there are others that should be considered [Aalst, 03a]: branching, interaction, optional tasks, etc.
- The *temporal* perspective is concerned with the temporal relationships between two *goals* that have to be attained in parallel (e.g. the *goals* have to

be developed at the same time). This perspective is related with the level of coupling identified in [Pinelle, 03].

- The *information* perspective (or *data flow*) refers to the transfer of resources among *tasks*. Many times the result of one *task* must be transferred to another *task* when the first finishes, or some data between two parallel *tasks* must be shared during their performance [Lonchamp, 98].

### 3.2.2 Role

The *role* is an active entity which is responsible for performing the *task*. The *role* can be a single person or a group of several persons, who must collaborate to achieve the *goal*. For certain *tasks*, the *role* can be performed by a software agent (e.g. to assess an exercise). The perspectives considered in this entity are:

- The *organization* perspective is concerned with the aggregation of *roles* into groups and sub-groups. It should be possible to describe different relationships among them (e.g. *tutor, coordinator*).
- The *assignment* perspective is devoted to the allocation of participants to *goals*. In our proposal it refers to the transfer of *roles* from a parent *task* to the *roles* defined in its child sub-*tasks*. In this way, it is possible to assign different participants to different *goals*. There are different ways to perform such a transfer (pre-defined, conditioned, a certain role decides, etc.).
- The *authorization* perspective is concerned with the permission that *roles* have to access resources or to use their operations. A task may involve several *roles* working in an environment that aggregates various resources. But it should be possible to describe different capabilities in the use of the resources for each *role*. For example, during a brainstorm session some *role* may be authorized to moderate the discussion.

### 3.2.3 Environment

The *environment* is composed by resources (e.g. LOs, services) that may be used to carry out each *task*. The resources can either be consumed or produced by the *task*. The service concept represents any kind of computerized or non-computerized facility that provides certain functionality (e.g. a chat, a simulator). We identify the following perspectives in this entity:

- The *communication* perspective encompasses the process of transfer and exchange of information that takes place between *roles* [Ellis, 99] [Pinelle, 03]. Typical communication tools are: e-mail, desktop conferencing systems, chat, whiteboard, etc. The *co-operation* perspective is centered on the access and exchange of a shared set of data [Ellis, 99]. Examples of systems that provide these functionalities are shared editors, virtual whiteboards, shared repositories, etc.
- The *coordination* perspective is concerned with the management and control of the resources in the *environment*. It controls the interaction with the *task*, with other resources, and their use by *roles*. The functionalities involved in this perspective may be related with the *communication* perspective, the *co-*

*operation* perspective, or with the use of general tools. For example, in the *communication* perspective the conference and conversational models are used as underlying control mechanisms: the *conference model* describes the way roles may gain access to the communication facilities and the *conversational* model describes which conversational moves are allowed in the communication. In *co-operation* the functionalities involved are: coordination of simultaneous access (e.g. *floor control*), versioning of the shared resources, etc.

#### 3.2.4 Task

The *task* entity is the aggregation point where all the other entities are anchored. In addition, each *task* defines the relationships that it has with its contained sub-*tasks*. In this way, it is possible to design complex *tasks* with a well-defined structure, establishing the relationships among *roles*, *environments*, and *goals* required for the definition of the identified perspectives. We consider three perspectives at the *task* level:

- The *causal perspective* describes *why* the educational process is performed. It gives educational information about the learning goal or goals to be attained, the pedagogical approach, the background required, etc. The *causal* perspective is concerned with the definition of the educational features of the *task*. It is devoted to the description of the *task* in order to facilitate its reuse in different contexts and aggregations (e.g. a course, a curriculum). In addition to the establishment of a clear educational objective it also involves the definition of pre-requisites and meta-data.
- The *awareness* perspective refers to how what the other participants are doing or have done is made ‘visible’ or ‘available’ to participants. *Awareness* can be used for educational purposes in many ways. Usually, teachers need to obtain information about the actions of their learners, but learners may also require *awareness* of their mates. In order to give the information to the right participant and to avoid information overload, *awareness* should be focused, customized, and temporally constrained [Baker, 02]. This perspective may be related with that of participant portfolios. Portfolios gather all the activities and work that a learner performs and may be used to assess the learner’s progress.
- The *decision making* perspective describes the way in which decisions are adopted. During a *learning activity* there are issues (e.g. when to finish the task, how to decide who the members of a group are) that may be decided by a certain role (e.g. teacher) or by a group according to a rule (e.g. voting, consensus).

These last two perspectives are different from the other ones. Both *awareness* and *decision making* involve the management of elements considered in the other perspectives. For example, *awareness* information can be provided about the participants’ assignment, the temporal achievement and sequencing of tasks or the actions performed on certain resources. In a similar way, *decision making* may be concerned with the permission that is offered to a certain role, the decision between two alternative tasks, or the way a group of participants may communicate using a certain tool.

## 4 Description of Perspectives

In the previous section we have identified a set of perspectives that should be considered in the design of learning experiences. For each perspective we are working towards the identification of the different forms that may be involved. We are looking for basic constructions or building blocks at a lower level, namely patterns, which might be used to arrange the behavior considered in such perspectives. In this way, it could be possible to combine these basic building blocks to construct more complex high-level behaviors. We will use the perspectives and patterns as use cases to drive the development of a new EML meta-model.

To carry out this work we are using results already present in the literature, such as the mechanics of collaboration for human-machine interaction collaboration analysis [Pinelle, 03], CSCW patterns [Lonchamp, 98], or workflow patterns for control and data flow, [Aalst, 03a] [Rusell, 04a] [Rusell, 04b] respectively:

- The mechanics of collaboration are the basic operations of teamwork, the small-scale actions and interactions that group members must carry out in order to get a task done in a collaborative fashion. They cover two general types of activity: *communication* and *coordination*. Communication is divided into two categories: explicit communication and information gathering. Coordination is broken into two categories: shared access and transfer. For each one of these categories various basic actions have been identified. For example, coordination mechanics for collaborative management of resources are presented in Table 1.

| Category | Mechanic | Typical Action |
|---|---|---|
| Shared access (to tools, objects, space, and time) | Obtain a resource | Physically take objects or tools<br>Occupy a space |
| | Reserve a resource | Move to a closer proximity<br>Notify others of intention |
| | Protect work | Monitors other’s actions in area |
| Transfer | Handoff object | Physically give/take object |
| | Deposit | Place an object in a place and notify |

*Table 1: Mechanics of Collaboration for coordination [Pinelle, 03]*

- In a similar way, workflow patterns for control flow gather common behaviors present in the *sequencing* of activity flows. These patterns range from very simple patterns such as sequential routing to complex patterns involving complicated synchronizations, such as the discriminator pattern, which supports the disabling of one activity according to a certain result. These patterns are classified into six categories: Basic, Advanced Branching and Synchronization Patterns, Structural, Involving Multiple Instances, State-based and Cancellation.

- *Object transfer* involves the communication of objects among different tasks. It is related with the *information* perspective. Very often, it is directly related to the sequencing of activities, but in other occasions different behaviors are possible. [Lonchamp, 98] distinguishes between synchronous or asynchronous data flows and the sharing of documents. Using these basic constructs it is possible to construct more complex behaviors such as: master-slave, producer-reviewer, collective synchronization, etc. In addition to collaborative data patterns, [Rusell, 04a] proposes workflow patterns for data flow and identifies four categories: data visibility, data interaction, data transfer, and data-based routing.
- One important issue in the workflow systems is how resources are assigned to tasks. This is the *assignment perspective* concerned with the assignment of participants to tasks introduced in section 3.2.2. The workflow domain is concerned with the manner in which tasks are advertised and assigned to specific resources (learners and academic staff) for execution. There are different ways in which a task may be assigned to a resource [Rusell, 04b]: (i) a task may be offered to a single role; (ii) a task may be offered to multiple roles; and (iii) a task may be pre-emptively assigning the task to a resource. IMS-LD uses a pre-emptive assignation mechanism that has no variant.

## 5 Conclusions

During the last few years, learning experiences carried out in e-learning systems are experiencing a shift in focus from contents to activities. This situation is promoted by the need to provide better learning events to learners according to current pedagogical approaches and to recent technological developments. On the one hand, there is a great interest in constructivist and social instructional theories that require learners to be involved in actual activities. On the other hand, current technological developments allow support and management of the interactions required in general learning scenarios; computer-based applications may be used to provide a broad range of functionalities: control flow, data flow, authorization, participant management, coordination, communication, co-operation facilities, etc. The challenge to match both issues is to provide mechanisms that enable teachers to design learning experiences as they desire, and to represent them in a way that enables the provision of appropriate computational support.

EMLs have been proposed to support the modelling of learning experiences in a broad way. They provide a meta-model that educational designers may use to design learning experiences, not simply to consider the modelling of learning contents, but also to enable the description of learning activities. This involves a shift in the way

LOs were conceived towards a more structured concept (UoLs), thus enabling the provision of an enhanced computational support.

Current EMLs consider elements and relationships required for modelling the more common perspectives involved in learning activities. But they do not provide a good support to model other perspectives involved mainly in collaborative learning scenarios. In this paper we have considered the main issues, perspectives and patterns that should be regarded in the support of these scenarios, focusing on the achievement of a clear separation of concerns. It is the first step toward the eventual proposal of an EML meta-model.

**Acknowledgements**

We want to thank the Spanish "*Ministerio de Educación y ciencia*" for its partial support for this work under the grant "*MetaLearn: methodologies, architectures and languages for E-learning adaptive services:*" (TIN2004-08367-C02-01).

## References

[Aalst, 03a] Aalst, W.M.P. van der, Hofstede, A.H.M. ter, Kiepuszewski, B., Barros, A.P.: "Workflow Patterns"; Distributed and Parallel Databases, 14, 3 (2003), 5-51.

[Aalst, 03b] Aalst, W.M.P. van der, Weske, M., Wirtz, G.: "Advanced Topics in Workflow Management: Issues, Requirements, and Solutions"; Transitions of SDPS, 7, 1 (2003), 49-77.

[Baker, 02] Baker, D., Georgakopoulos, D., Schuster, H.: "Awareness Provisioning in Collaboration Management"; Cooperative Information Systems, 11(1&2) (2002), 145-173.

[Beetham, 04] Beetham, H., Review: "Developing e-Learning Models for the JISC Practitioner Communities"; version 2.1, JISC e-Learning and Pedagogy Programme (2004).

[Dillenbourg, 02] Dillenbourg, P., Over-scripting CSCL: "The Risks of Blending Collaborative Learning with Instructional Design"; In Kirschner, P. A. (Ed.): "Three worlds of CSCL. Can we support CSCL", Heerlen, Open Universiteit Nederland (2002), 61-91.

[Duval, 02] Duval, E., (Ed.): "Learning Object Metadata Standard" IEEE 1484.12.1 official standard (2002).

[Ellis, 99] Ellis, C., Wainer, J.: "Groupware and Computer Supported Cooperative Work" In Weiss, G. (Ed.): "Multiagent Systems: A Modern Approach to Distributed Artificial Intelligence"; the MIT Press (1999), 425-457.

[Guareis, 00] Guareis de farias C. R., Ferreira L., Sinderen M. J. van: "A Conceptual Model for the Development of CSCW Systems"; 4th Int. Conf. Design of Cooperative Systems (2000).

[Koper, 01] Koper, E.J.R.: "Modeling Units of Study from a Pedagogical Perspective – The Pedagogical Metamodel behind EML"; Open University of the Netherlands (2001).

[Koper, 03a] Koper, E.J.R.: "Combining Re-usable Learning Resources and Services to Pedagogical Purposeful Units of Learning"; In Littlejohn, A. (Ed.): "Reusing Online Resources: A Sustainable Approach to eLearning"; London: Kogan Page (2003), 46-59.

[Koper, 03b] Koper, R., Olivier, B., Anderson, T. (Eds.): "IMS Learning Design Information Model"; IMS Global Consortium (2003).

[Lonchamp, 98] Lonchamp, J.: "Process Model Patterns for Collaborative Work" 15th IFIP World Computer Congress, Telecooperation Conference, Viena (1998).

[Paquette, 03] Paquette, G.: "Educational Modeling Languages: from an Instructional Engineering Perspective"; In "Accessible Education Using Learning Object" (2003).

[Pinelle, 03] Pinelle, D., Gutwin, C., Greenberg, S.: "Task Analysis for Groupware Usability Evaluation: Modeling Shared Workspace Task with the Mechanics of Collaboration"; ACM Transactions on Computer-Human Interaction, 10, 4 (2003), 281-311.

[Rusell, 04a] Rusell, N., Hofstede, A. H. M. ter, Edmond, D., Aalst, W. M. P. van der: "Workflow Data Patterns"; Technical Report, FIT-TR-2004-01, QUT (2004).

[Russell, 04b] Russel, N., ter Hofstede, A. H. M., Edmond, D., van der Aalst, W. M. P. "Workflow Resource Patterns"; Technical Report, FIT-TR-2004-01, QUT (2004).

[Strijbos, 04] Strijbos, J. W., Martens, R. L., Jochems, W. M. G.: "Designing for Interaction: Six Steps to Designing Computer-supported Group-based Learning"; Computers & Education, 42 (2004), 403-424.