Modeling units of learning from a pedagogical perspective

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1. Introduction

The title of this chapter could have been: where is the *learning* in eLearning? The promise of eLearning, and the enabling learning technologies, is to make learning experiences in all types of settings more effective, efficient, attractive and accessible to the learners. In eLearning the Internet is used as the core medium for the delivery of information and the support of communication. Most people also think that the Internet, itself, as the key factor in the success of eLearning. However, a vast amount of research provides evidence for the proposition that it is not the medium (Internet), itself, which is accountable for the accomplishment of these promises, but the pedagogical design used in conjunction with the features of the medium (we refer to the classical medium discussions by Clark, 1983, 1986, 1990, 1999 and Kozma, 1991). The message is that we should concentrate on the quality of the pedagogical design and its relationship to the possibilities of the Internet if we want to accomplish the promises of eLearning.

Another common belief is that learning is the same as knowledge transfer. The idea which comes with it, is that it is enough to make knowledge available to learners according to some pedagogical structure. However, providing adequate knowledge is not enough: it has to be *learned*. It is this learning process that is the process we are putting at the centre when we discuss instructional design or learning design. Ask yourself: 'where is the *learning'* in eLearning? On top of that, 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, interacting in their social and work situation.
A lot of research about learning processes provides evidence for this stance that learning doesn't come from the provision of knowledge solely, but that it is the activities of the learners into the learning environment that are accountable for the learning. This is not to say that knowledge objects are not of importance in learning situations, but that they are not the key thing in effective learning processes.

This chapter will address the topic of the pedagogical design of learning events. Learning events are offered mostly in chunks, like courses. These chunks (in the next paragraph we abstract them to the concept of 'units of learning') are the major delivery units for eLearning. From a design perspective, the course is the aggregate containing all the necessary features to make learning successful. It is at this level that educational modelling (or "learning design") takes place; it is at this level that the pedagogical models are implemented; it is this level of aggregation that is accountable for the quality of learning.

2. Learning design is modelling 'units of learning'

In 1998, a research project started at the OUNL aimed at building a semantic notation for complete units of learning to be used in eLearning. The concept of 'unit of learning' is central to this case. It is the smallest unit providing learning events for learners, satisfying one or

[1] This chapter is an abstracted version of the paper published at: http://eml.ou.nl/introduction/articles.htm (Koper, 1991).

more interrelated learning objectives. This means that a unit of learning cannot be broken down to its component parts without loosing its semantic and pragmatic meaning and its effectiveness towards the attainment of learning objectives. The unit of learning could be considered as a *gestalt.* In practice you see units of learning in all types, sorts and sizes: a course; a study program; a workshop; a practical; a lesson could all be considered to be a unit of learning.
A unit of learning could be delivered through what is called:

- Online learning (completely through the web).
- Blended learning (mix of online and face-to-face)
- Hybrid learning (mix of different media: paper, web, e-books, etc.).

We called the notation of units of learning an "Educational Modelling Language" or EML (e.g. Koper *et al*, 2000). The EML specification has been further elaborated in the IMS context and was the base for the current IMS Learning Design Specification (IMSLD, 2003). In this text we will refer to these specific implementations as: EML/IMSLD.

3. The learning objects model

A learning object is any entity, digital or non-digital, that can be used, re-used, or referenced during technology-supported learning (IEEE LTSE). Examples of learning objects are: printed materials, study tasks, exercises, study texts, cases, media assets, courses, study programs and also persons. A fundamental idea is that a learning object can stand on its own and may be re-used (see also Koper, 2003). In practice this means that learning objects are mostly smaller objects – smaller than courses - that can be re-used in different courses. One of the underlying ideas is that courses in themselves can hardly be made re-usable, because of all sorts of local factors (see e.g. Downes, 2000). Only some institutions are really successful in course exchange, but most institutes share learning objects such as textbooks or geographical maps.

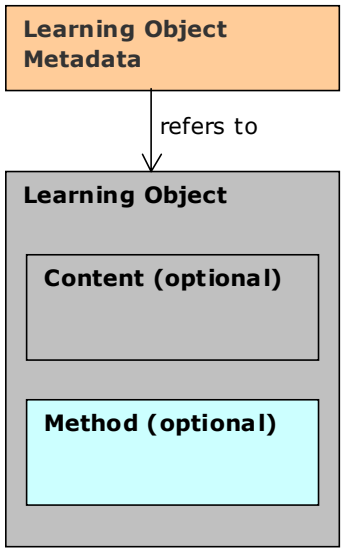

Figure 1. A common view of learning objects and its metadata.

There are several ways of viewing learning objects. Learning objects are entities that may be referred to with metadata. The metadata itself are separate from the object it refers to. The metadata, and sometimes the learning objects itself, may be stored in databases. The metadata specification is described in the IEEE LTSC-LOM () standard specification. In principle learning objects have content (attributes and other learning objects) and descriptions of the behaviour of the learning object (operations). It is clear that the idea of a

learning object model conforms to the principles of objects in the theories of object-orientation. Content packaging specifications organize and transfer series of learning objects.

The major question from a perspective of use in real educational practice is: does this model of learning objects and packages provide us sufficient means to build complete, flexible and valid units of learning to be delivered through learning management systems?

The answer is clearly 'no'. From an educational perspective it is not enough to have learning objects and metadata as such. Different types of learning objects have different functions in the context of real education. A study task and a study text have both a different function in a unit of learning. Also, there are different constraints in the relations between different types of learning objects. A study task (a type of learning object), for example, almost always refers to resources (other types of learning objects) needed to perform the task. So there is a structural relationship between tasks and resources within the context of a unit of learning.

The major problem with the learning objects model as it is applied until now, is that learning objects are not typed to their usage in the context of a unit of learning. The learning object model expresses a common overall structure of objects within the context of a unit of learning, but does not provide a model to express the semantic relationship between the different types of objects in the context of use in an educational setting. As a result, the learning object model also fails to provide for a model of the structure of the content of the different objects. The typing of objects also varies according to different pedagogical stances, so there is a need for a meta-model to describe the relationships. The basic idea, we have elaborated, is to:

1. Classify, or type, the learning objects in a semantic network, derived from a pedagogical meta-model,
2. Build a containing framework expressing the relationships between the typed learning objects and
3. Define the structure for the content and behaviour of the different types of learning objects.

This approach has a lot of advantages, such as the following:

- It supports developers in building valid and high quality units of learning, using and re-using smaller components;
- It supports builders of authoring and delivery tools by providing a common framework for valid units of learning;
- Learners and teachers can identify and search learning objects, knowing their function within the framework of the course;
- It provides a semantic expression for the content of learning objects, supporting re-use, interoperability and assembly of the components of units of learning into different units of learning.

4. Requirements for units of learning as a result of learning design

Actors in the learning process, dealing with units of learning are:

- Learners
- Staff
- Developers of units of learning, or the components it refers to like study materials

Besides these direct users of the system there are lots of other different actors in eLearning, specifically all types of managers (system managers, HRM managers, etc.), vendors and publishers. The role developer may (e.g.) be split by: author, interaction designer, graphical designer, etc.

In our use case analysis of the actor requirements (including the once not mentioned here), they all want four different types of outcomes from eLearning. They want more effectiveness, more efficiency, more attractiveness and higher accessibility. All stakeholders fill these aspects from their own perspective. The translation in general categories of requirements are as follows:

An Educational Modelling Language, which describes a unit of learning, must meet the following general requirements:

1. The notational system must describe units of learning in a formal way, so that automatic processing is possible (*formalization*).
2. The notational system must be able to describe units of learning that are based on different theories and models of learning and instruction (*pedagogical flexibility*).
3. The notational system must explicitly express the semantic meaning of the different learning objects within the context of a unit of learning. It must provide for a semantic structure of the content or functionality of the typed learning objects within a unit of learning, alongside a reference possibility (*explicitly typed learning objects*).
4. The notational system must be able to fully describe a unit of learning, including all the typed learning objects, the relationship between the objects and the activities and the workflow of all students and staff members with the learning objects (*completeness)*. And regardless of whether these aspects are represented digital or non-digital.
5. The notational system must describe the units of learning so that repeated execution is possible (*reproducibility*).
6. The notational system must be able to describe personalization aspects within units of learning, so that the content and activities within units of learning can be adapted based on the preferences, prior knowledge, educational needs and situational circumstances of users. In addition, control must be able to be given, as desired, to the student, a staff member, the computer or the designer (*personalization*).
7. The notation of content components, where possible, must be medium neutral, so that it can be used in different publication formats, like the web, paper, e-books, mobile, etc. (*medium neutrality*).
8. Separation between the description standards and interpretation technique. Through this, investments in educational development will become resistant to technical changes and conversion problems (*interoperability and sustainability).*
9. The notational system must fit in with available standards and specifications (*compatibility).*
10. The notational system must make it possible to identify, isolate, decontextualize and exchange useful learning objects, and to re-use these in other contexts (*reusability*)*.*
11. The notational system must make it possible to produce, mutate, preserve, distribute and archive units of learning and all of its containing learning objects (*life cycle*).

5. The pedagogical meta-model

What is a pedagogical meta-model? In our view it is a model of pedagogical models. This means that specific pedagogical models, like the problem-based learning models or the collaborative learning models, could be described (or derived) in terms of the meta-model. This is of importance when you want to express semantic relationships between pedagogical entities *and* want to be pedagogical neutral. Compare this for instance with a text editor like MS-Word. MS-word is neutral to the type of text you can edit with it. You can imagine what great help it would be when these types of tools are aware of the type of content you are editing. You could expect a lot more support in the writing process than you get now. Text writing has so many varieties in practice that a real semantic framework for texts in general is not available at the moment, and it maybe never will be. However, education is a more restricted domain with a lot of commonalities in its instances. This is mainly due to the hard

work done in research into learning and instruction. There are still a lot of different stances when answering questions about learning, but there are also a lot of commonalities. These commonalities are the focus of a meta-model, the differences are made by parameterisation of the meta-model. This idea has led us to the work on the meta-model behind EML/IMSLD.

The main topics of the static structure of the pedagogical meta-model are expressed in UML diagrams here (see: OMG; Booch, Rumbaugh, & Jacobson, 1999). The pedagogical semantics of EML/IMSLD are designed according to this model. The model is based on educational research, specifically in the field of learning psychology and instructional design (e.g. ; De Block, 1982; Duffy & Jonassen, 1991; Duffy & Cunningham, 1996; Gagné, 1977; Gagné & Briggs, 1979; Jonassen, 1999; Mayer. & Greeno, 1972; Merrill, 1983; Merrill, 1999; Reigeluth& Schwartz, 1989; Reigeluth, 1999; Reigeluth, & Stein, 1983; Reigeluth, 1983; Van Merriënboer, 1997). Most of these models in literature are expressed in natural language and ad hoc schemas. Like all models this model abstracts reality. Course designs are something different from what actually happens when courses are instantiated and used in real practice. It is not the intention of course designs to abstract all the details of the course, but its major points.
Also, the UML diagrams are expressions of the pedagogical models underlying units of learning. It highlights the important points. In its details of implementation the models have more complexity.

First the major packages of the pedagogical meta-model are shown in figure 3.

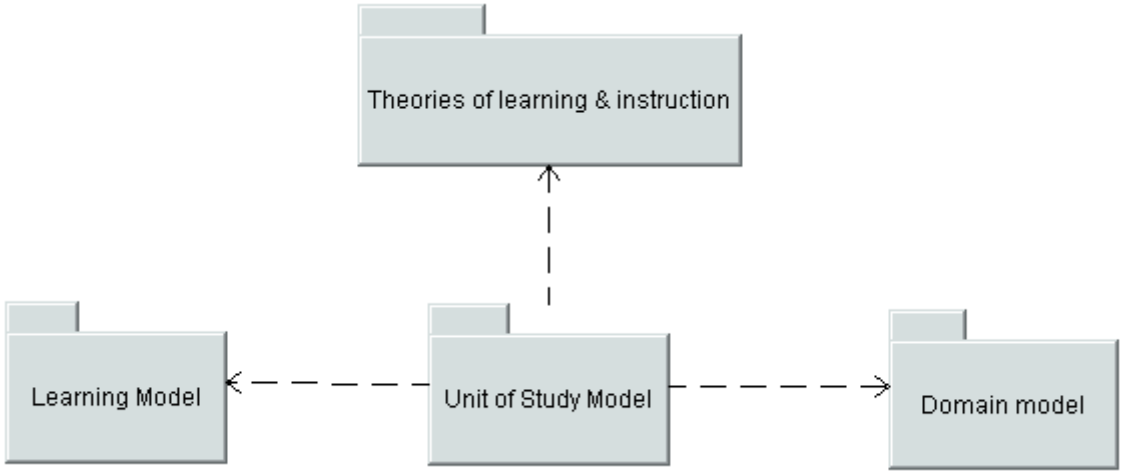

Figure 3. Packages in the metamodel.

There are four packages:
1. The learning model, which describes how learners learn based on commonalities (consensus) in learning theories.
2. The unit of learning model, which describes how units of studies which are applicable in real practice are modelled, given the learning model and given the instruction model.
3. The domain model, which describes the type of content and the organization of that content. For example, the domain of economics, law, biology, etc.
4. Theories of learning & instruction, which describe the theories, principles and models of instruction as they are described in literature or as they are conceived in the head of practitioners.

5.1. Part 1: The learning model

Figure 4 provides a summary of the learning model.

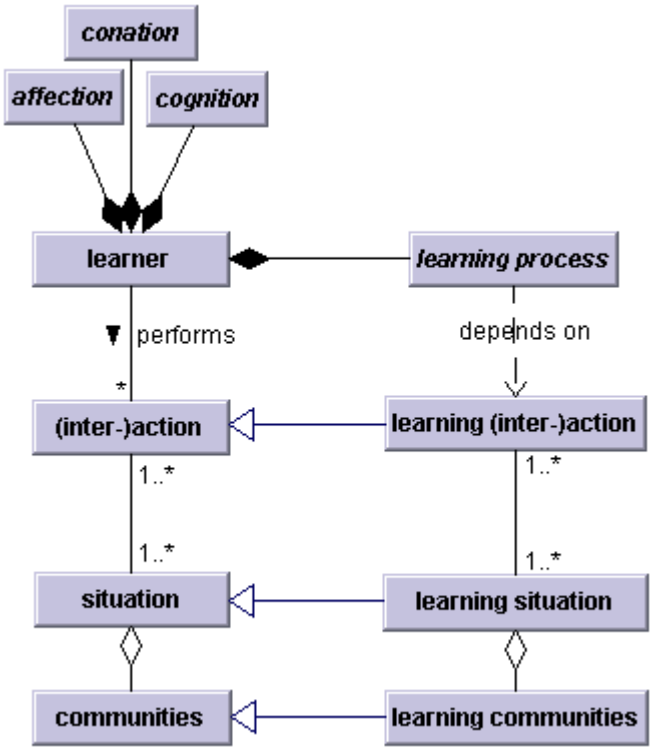

Figure 4. The learning model.

The learning model is based on the following axioms:

1. A person learns by (inter-) acting in/with the external world.
2. The real world could be considered to be composed of social and personal situations, which provide the context for actions.
3. A situation is composed of a collection of things and living beings in a specific interrelationship.
4. One part of these situations are communities of practice and – more specifically – learning communities.
5. There are different types of learning, the one of interest to us is learning invoked by instructional measures.
6. Learning can be considered to be a change in the cognitive or metacognitive state. However, changes in the connation and affection can also be considered as the result of learning. When a person has learned he or she can a) carry out new interactions or carry out interactions better or faster in similar situations, or b) carry out the same actions in another situations (transfer).
7. A person can be urged to carry out specific interactions, if:
   - a person is willing to do so or stimulated to do so (conation / motivation factor);
   - a person is able to do so (cognition factor);
   - a person is in the mood to do so (affection / emotional factor);
   - a person is in the right situation to do so (situational factor);
8. What has been set out here regarding an individual is also valid for a group of people or an organization, even though this does not have to be reducible to individuals.

The essence here is that no value judgment is made in these axioms about the following questions:

1. What does a person or group learn (knowledge, competencies, skills, insight, attitudes, intentional behaviour) and in which domain?
2. What kinds of activities must be carried out to learn? For example: observing, describing, analysing, experiencing, studying, problem solving, experimenting, predicting, practicing, exploring and answering questions.
3. How should a learning situation be arranged (context, which people, which objects) and what relationship does the situation have to the teaching-learning process?
4. To what extent are the components of the situation present externally and to what extent are they represented cognitively-internally?
5. How, precisely, do the learning and transfer processes occur?
6. How is motivation stimulated?
7. How is the learning result captured?
8. How should activities be stimulated?

The answers to precisely these questions determine the educational philosophy, the instructional model and the more practical design of the units of learning. The meta-model provides the semantic framework for the units of learning's notational system, alongside the structure of learning environments that was dealt with earlier.

A citation from Duffy & Cunningham (1996, p. 171) in this area: 'as the quote from Skinner suggests, everyone agrees that learning involves activity and a context, including the availability of information in some content domain. Traditionally, in instruction, we have focused on the information presented or available for learning and have seen the activity of the learner as a vehicle for moving that information into the head. Hence, the activity is a matter of processing the information. The constructivists, however, view the learning as the activity in context. The situation as a whole must be examined and understood in order to understand the learning. Rather than the content domain sitting as central, with activity and the 'rest' of the context serving a supporting role, the entire gestalt is integral to what is learned.'

5.2. Part 2: The unit of learning model

Figure 5 describes the unit of learning model.

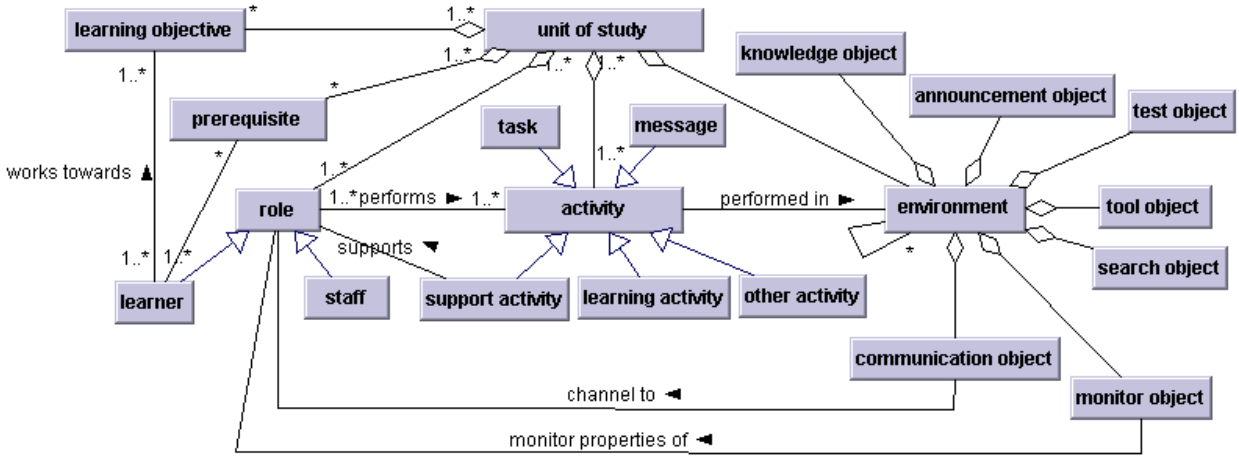

Figure 5. The unit of learning model.

A model for a unit of learning is the result of a learning design process in which a real product (the unit of learning) is the result. It must take into account issues such as:
- The roles of staff and learners in the learning process
- The learning objectives and target group

- The prerequisites of the learners
- Other learner characteristics (learning styles, preferences, situational circumstances, etc.).
- The domain of learning (e.g. mathematics is different from cultural sciences)
- The context of learning (distance learning, blended learning, support structure available, library, etc.)
- The assessment of learning

In this model terms like 'activity' and 'environment' are used as counterparts for 'action' and 'situation' in the learning model. However, in the unit of learning model, they refer to *planned* activities and environments. In essence this is the difference between the two models: the unit of learning model deals with the design of learning processes and the learning model deals with the way learning takes place in real.

In EML/IMSLD we must take care that all these different information categories could be described in meaningful semantic terms and not restricted to one of the views of teaching and learning models.

5.3. Part 3: The domain model

Every pedagogical model must take into account the characteristics of the content domain. Content domains are e.g. mathematics, cultural science, economics, psychology, electrical engineering, law, etc. Every content domain has its own structuring of knowledge, skills and competencies. There are different cultures and communities of practice. Often there are also specifically designed pedagogical models for the domain. For instance in mathematics teaching.

5.4. Part 4: Theories of learning and instruction

Figure 6 provides a model of the generalization relationships between instruction models.

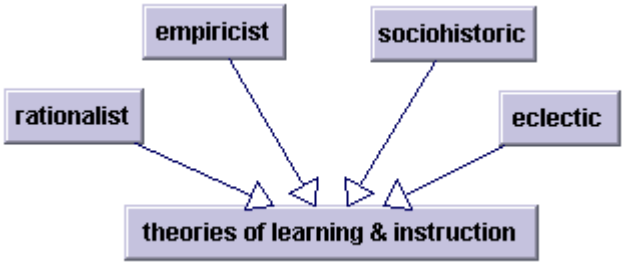

Figure 6. Theories of learning & instruction.

In educational technology, there are different streams in which the characteristics appear to have what Thomas Kuhn (1962) describes as scientific paradigms. Greeno, Collins & Resnick (1996) make – in a meta-analysis – a distinction between three major streams of instructional theories:

1. Empiricist (behaviourist)
2. Rationalist (cognitivist and constructivist)
3. Pragmatist-sociohistoric (situationalist)

All stances have different views on topics such as: knowledge, learning, transfer and motivation. Some of the differences are:

According to the *empirical approach,* as typified by Locke and Thorndike, all reliable knowledge is based on experience. Locke says: 'There is nothing in the mind that was not in the senses.' The assumption is that behaviour is predictable, given he specific environmental conditions, and that processes can be analysed in isolation. The idea is that learning can influence outside of its context and without knowledge of the internal learning processes.

In the *rationalist approach,* as typified by Descartes and Piaget, thinking is considered the only reliable source of knowledge. In this case, it is supposed that cognition mediates the relationship between a person and the environment. As there is the possibility of large individual differences in cognitive processing, for example, because of differences in prior knowledge (Dochy, 1992), meta-cognition (Flavell, 1979; Brown, 1980), motivation (Malone, 1981) and learning styles (Vermunt, 1996), the assumption of predictable behaviour falls away, and those involved must work with more open, authentic environments in which students themselves can build knowledge. The student is given a central, self-managing role in the educational process (Shuell, 1988; Schunk & Zimmerman, 1994).

The third approach is called the *pragmatic and cultural-historic* approach, as typified respectively by James, Dewey and Vygotsky, Leont'ev, or in educational theory as *social constructivism* (Simons, 1999). In this approach, the situation and the cultural-historical context that a learner is in are given primary attention (Lave & Wenger, 1991; Cole & Engestrom, 1993). Knowledge is distributed among individuals, tools and communities, such as those of professional practitioners. The assumption is that there is collective as well as individual knowledge. Learning is considered as the adaptation of behaviour to the rules of the community.

Based on these stances there are – in literature - descriptions of hundreds of more theoretical or practical theories and models of learning and instruction. To name but a few: competency based learning, project based learning, mastery learning, problem based learning, case based learning, experiential learning, action learning, etc. (see literature like Reigeluth, Merrill, Jonassen, Kearsly). Also lots of more informal teaching plans are available (see e.g. Eric's lesson plans at: http://ericir.syr.edu/Virtual/Lessons/). Another approach is based in human resource management, mostly referred to as performance improvement (sometimes human performance technology, see Stolovitch & Keeps (1999) for an overview).

Most of these models were studied and analysed. The commonalities were mapped and the differences listed in order to derive the meta-model.

Also a fourth type of model was added: the eclectic model. These are instructional design models using principles from different stances, just for the practical occasion. These models can be explicitly formulated, but mostly they are implicit.

5.5. An integrated picture of the meta-model

The integrated picture of the meta-model could be drawn as in figure 7. The focus in the model is also on the learner and not on the role of staff. It is drawn here to trace the dependencies within the model.

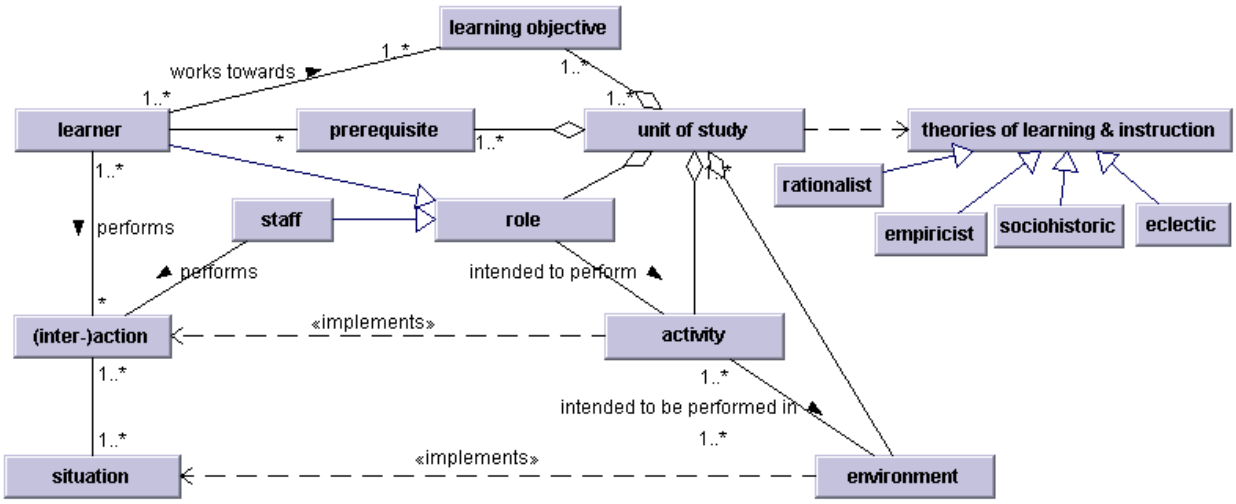

Figure 7. A picture of the integrated model.

Implied elements
Not all pedagogical models address all elements in an explicit way. Sometimes these elements are kept *implicit*. For instance: there are learning management systems that don't provide activities to learners and/or staff. This can mean two things:

1. The activities are implied, the students have to find them out themselves. Mostly this is the case with classical forms of education with a lot of standard, quite evident, tasks, such as: "read this book", "solve this problem", "answer the questions".
2. The activities are not implied, but they are not part of the course offered through an LMS. The idea is that teachers will set the activities for students. This is the case in classroom situations. The LMS only serves some environment functions like communication facilities and learning resources. In this case the LMS cannot support units of learning, only parts of it to be integrated by the teachers. The LMS isn't really a platform for all eLearning situations.

6. Conclusions

In this chapter the pedagogical meta-model behind EML/IMSLD is presented. In our analysis the current thinking about 'learning objects' has some shortcomings. These were addressed and a containing framework for typed learning objects was provided. This framework ensures that the structure of the units of learning used in eLearning is valid. However, this is at itself not the same as an effective, efficient and attractive pedagogical design; whether a design conforms to these criteria comes for a large part from the theories and principles of learning and instruction. These theories form the basis for the design of the meta-model behind EML/IMSLD. On the other hand, the designs themselves are not enough to guarantee high quality designs. They tend to be defined at too abstract a level, not providing enough details for the real structuring work that must be done when developing real units of learning.

EML/IMSLD makes the use of pedagogical models explicit. This is one of the factors needed to enhance the quality of a pedagogical design. So the combination of good design and good structuring of the design in a notation will bring us the quality of learning we are searching for. EML/IMSLD provides the framework to notate and communicate the designs in a complete form, validate them on completeness in structure, makes it possible to identify the functionality of learning objects within the context of a unit of learning and provides means for real interoperability and re-usability. Moreover, we think that EML/IMSLD can make the building of learning management systems easier (because the requirements are explicit)

and can make learning management systems more effective, because the design of the systems can take advantage of the huge body of knowledge available in educational research, based on theories, empirical findings and the experience from practitioners.

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