# Educational Modelling Language

Chapter 7

# EDUCATIONAL MODELLING LANGUAGE

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## 1 INTRODUCTION

This chapter is about an open learning technology specification called Educational Modelling Language (EML, 2000). EML is the first implementation of a general set of notions as presented in the domain model for integrated e-learning in chapter 6.
The development of this language should be seen in the broad perspective of working towards an instrumentation for the creation of effective, efficient and attractive integrated e-learning environments. In chapter 1 it was stressed that requirements for e-learning environments are becoming more complex, increasing the need for an integrated approach. The challenge for the development of EML was to adhere to these requirements.

EML is defined as: '*An EML is a semantic information model and binding, describing the content and process within a 'unit of study' from a pedagogical perspective in order to support reuse and interoperability'* (Rawlings, van Rosmalen, Koper, Rodrigues-Artacho & Lefrere, 2002).

The next paragraphs provide a closer look at EML (version 1.0) and its background. First, the general requirements, which have led to the design and development of EML, are discussed. These requirements have amongst others led to the construction of a pedagogical meta model to meet the demand of supporting a variety of educational notions and settings. The meta model will be discussed the conceptual structure of EML and the corresponding XML-binding are also described.

A main part of this chapter describes how EML can be used and what it looks like by presenting several examples. These examples follow a series of design steps needed to implement a pedagogical design in EML. Several screenshots of the so-called Edubox system are provided to show how these examples can be interpreted. Edubox is an application that is able to process EML encoded files by publishing them to the world-wide-web.

In the concluding paragraphs EML is evaluated in the light of the stated requirements, in particular the intended pedagogical flexibility; this chapter finishes with the evolution EML is undergoing at a worldwide perspective.

## 2. REQUIREMENTS

Koper (2001) summarized eleven requirements that an educational modelling language should meet. These requirements are:

1. *Formalisation:* EML must be able to describe pedagogical models in a formal way, so that it is machine-readable and automatic processing is possible .
2. *Pedagogical flexibility:* EML must be able to describe units of study that are based on different theories and models of learning and instruction.
3. *Explicitly typed learning objects:* EML must be able to express the semantic meaning of different learning objects within the context of a unit of study.
4. *Completeness*: EML must be able to describe a unit of study completely, 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.
5. *Reproducibility*: EML must describe the units of study so that repeated execution is possible.
6. *Personalisation*: EML must be able to describe personalisation aspects, so that the learning materials and learning activities can be adapted based upon preferences, prior knowledge and educational needs.
7. *Medium neutrality*: The notation of units of study, where possible, must be medium neutral, so that it can be used in different publication formats, like the web, paper, e-books, mobile, etc.
8. *Interoperability and sustainability*: Separation between the description standards and interpretation technique. Through this, investments in educational development will become resistant to technical changes and conversion problems.
9. *Compatibility*: EML must fit in available standards and specifications.
10. *Reusability*: EML must make it possible to identify, isolate, decontextualize and exchange useful learning objects, and to reuse these in other contexts.
11. *Life cycle*: EML must make it possible to produce, mutate, preserve, distribute and archive units of study and all of its containing learning objects."

Three requirements will be elaborated in the following, as they have played an important role in the design and development of EML

### 2.1 Formalisation

This is arguably the most important requirement for an e-learning environment, as it is the is guaranteeing that the resulting binding can be processed by computers. The requirement implies that EML should be a formal language, with its own alphabet, words and syntax.

Be aware that processing doesn't mean that computers can really understand the language. For the specification to become machine understandable, the semantics expressed by the formal language could eg be interpreted with future artificial intelligence means.

## 2.2 Pedagogical flexibility

An important requirement of EML is pedagogical flexibility. This requirement was derived from the changing landscape of training and education. New paradigms of teaching and training are a fact of life now. For instance competency based learning (Schlusmans, et al, 1999), collaborative learning (Dillenbourg & Schneider, 1995), performance improvement approaches (Robinson & Robinson, 1995). Most of these new learning paradigms are based on constructivist principals (Brown, Collins, & Duguid, 1989). These new learning paradigms should be implemented in e-learning environments. In order to support these new paradigms, learning environments need to be rich, flexible environments, which are available anytime and anyplace (Scott Grabinger, 1996; Manderveld & Koper, 1999). However, most e-learning environments do not support a variety of pedagogical models. They provide their own (implicit) didactical premises or no didactics at all.

By defining the requirement of pedagogical flexibility, EML is safeguarded from a lack of supporting a variety of pedagogical models or none pedagogical model at all.

## 2.3 Interoperability

Educational institutes are increasingly faced with large investments in infrastructure and the problem of rapidly changing technology. Especially when course development and delivery are integrated into technology. Most e-learning environments develop and store courses and their contents in proprietary formats. As a result it becomes difficult or even impossible to export these courses and content to other formats (Koper, 2003). Cross-platform exchange of content is hardly possible. Often the only possible solution is to convert the content manually, which can be a time-consuming and expensive job. Major software upgrades sometimes also show the problem of lacking backwards compatibility thus causing manual conversion.

These problems cause a growing demand for interoperable solutions. Interoperability can be defined as 'the ability of a system or a product to work with other systems or products without special effort on the part of the customer' (http://whatis.com). The key issue in this respect is to create and manage information in such a way that opportunities for exchange and reuse of information, either within of between institutions, are maximised (Miller, 2000).

The reasoning above led to definition of interoperability as an important requirement of EML.

# 3 PEDAGOGICAL META MODEL

In the previous paragraph the requirement for pedagogical flexibility was described as the demand that the language to de designed should be able to elaborate different theories and models of learning and instruction. In order to meet this demand a pedagogical meta model has been designed, which should be neutral to the different approaches to learning and instruction.

The heart of such a model should be that it models other pedagogical models (Koper, 2001). This implies that this model serves as an abstraction. Specific pedagogical models, like problem based learning models or collaborative learning models, could be described in terms of the meta model. The pedagogical meta model is based upon research and literature on learning and instruction and instructional design theories (eg Reigeluth, 1987, 1999; Stolovitch & Keeps, 1999).

The meta model consists of five axioms. The most important axiom is that persons learn by performing activities in an environment in interaction with that environment. The other axioms are (see Koper, 2001):

1. When a person has learned, he is able (a) to perform new activities or perform activities better or faster in similar environments or he is able (b) to perform the same activities in different environments
2. An environment consists of a set of objects and/or human beings that are related in a particular way.
3. A person can be encouraged to perform certain activities when:
    a. This person, given the requirements in terms of prior knowledge, personal circumstances and the performance context, can perform the activities.
    b. The required environment is made available.
    c. The person is motivated to perform the activities.
4. What had been posed here with respect to a single person, also applies to a group of persons.

It can be concluded from the axioms that instruction should consist of providing students with coherent series of activities, including specific learning environments, so that learning actually can take place.

This pedagogical meta model also supports the first requirement of integrated e-learning, described in chapter 1, known as flexibility of educational setting.

## 4. EML

Based upon the requirements and the pedagogical meta model EML has been developed. In the following paragraphs EML is described from several points of view.

### 4.1 Conceptual structure

The conceptual model of the structure of EML is based upon the pedagogical meta model. The basic idea is shown in figure 1. The smallest autonomous part in education is labelled as a ‘unit of study’. This unit of study can take any form (course, workshop, lesson, etc), depending on its pedagogical function. Within the unit of study there are always one or more roles that can be defined, starting with the student role.

Students learn by doing things (‘Activities’) in a specific context (‘Environment’). These activities are in fact the stimuli offered to the student to invoke learning. Examples of activities are attending a lesson, studying a chapter, solving a problem, prepare of presentation and so on. However, these activities are not performed in a vacuum, but in a specific setting or environment. This environment consists of all kinds of objects like books, readers, teachers, fellow-students, libraries et cetera to make the actual learning possible.

This model applies to any pedagogical approach. From this respect EML should be able to handle all pedagogical flavours.

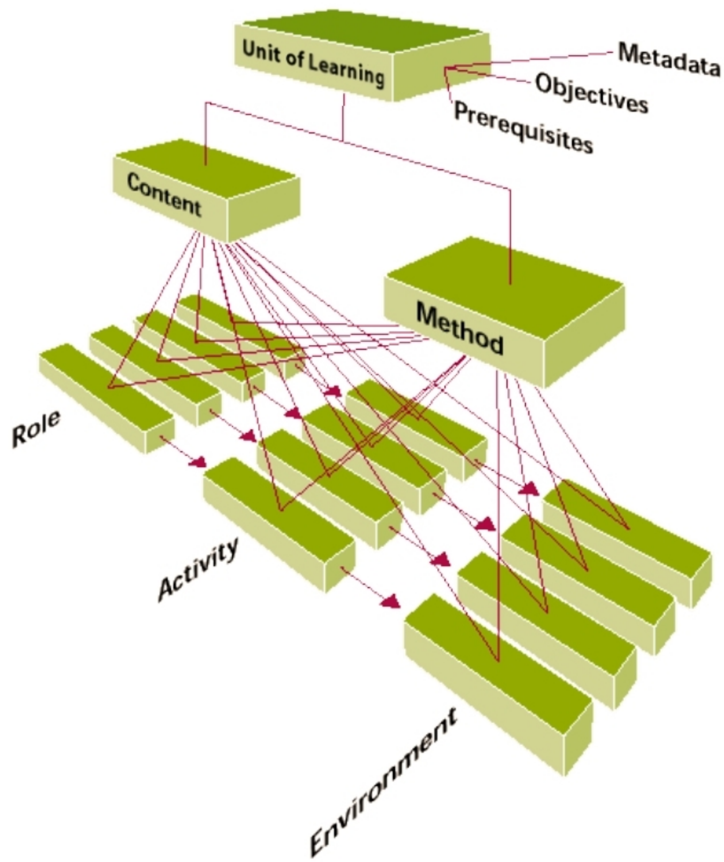



Figure 1: basic structure of EML (This a draft figure, the final figure will be provided)

The personalisation requirement has been worked out as follows. EML units of study contain all components that can create personalised learning paths based on individual student characteristics. The decision which characteristics are used and the way they influence the learning path is the choice of the educational designer. Show and hide conditions make it possible to provide the students with adapted units of study, which fit to their profiles. Parts of a unit of study that may hidden or shown may vary from specific content parts (e.g. a text section) to complete activity structures. Students’ profiles are made up from a combination of variable student properties. These properties may be set by students themselves, by other actors in the learning environment or by the system. Examples of these properties are variables like prior knowledge, learning style, preferences etc and are set at runtime. Within so called 'Conditions' in EML the rules can be written down for the hiding and showing components based on the properties.

4.2 XML-binding

Requirements for formalisation, medium neutrality and interoperability have led to the decision to implement EML as an XML-application (Bray, Paoli, & Sperberg-McQueen, 1998). XML (eXtensible Markup Language) is a general accepted meta language for the structured description of documents and data, based on the ISO-standard SGML.

Figure 2 shows the result of way the conceptual ideas behind EML are translated into an XML document type definition, or DTD. This DTD serves as a kind of format all EML-files must apply to.

The basic structure of the EML-DTD is shown in figure 2. Only a selection of the elements and relationships and no attributes are shown. All elements and attributes of EML are described in the EML reference manual (Hermans, Koper, Loeffen, Manderveld & Rusman, 2000), which can be downloaded from http://eml.ou.nl. The complete DTD can also be downloaded from http://eml.ou.nl.

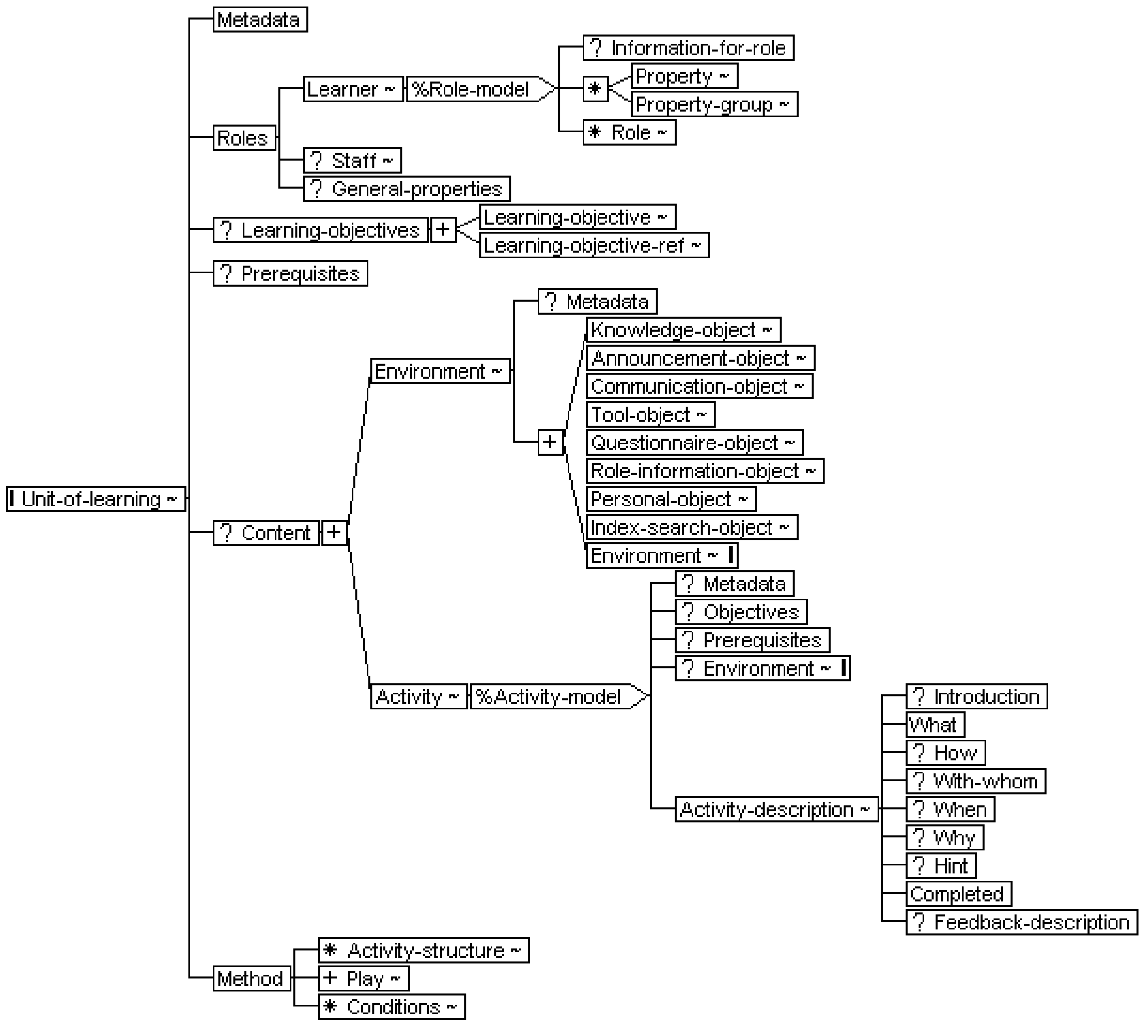



Figure 2: Basic structure of EML binding (This a draft figure, the final figure will be provided)

The figure shows the hierarchy of the unit of study. According to this structure each EML-file representing a unit of study should at least consist of metadata (general descriptive information), a role definition, and a method section. 'Content' covers activity descriptions and environment specifications, including all kinds of objects that can exist within an environment. Content is not a required part. When content is elsewhere available it can be included in the unit of study with referring mechanisms in the method.

## 5. DESIGNING WITHIN EML

Central starting point in creating a pedagogical design is the student who wants to learn. In order to attain the objectives of a unit of study students have to respond to the stimuli (activities) presented in the learning environment. The learning path and support environment reflect the advocated pedagogical principles. In this way, EML is not pedagogically prescriptive, but enables to implement ones own pedagogical choices.

This paragraph describes the steps to be taken in order to implement a pedagogical design in EML. Several EML-examples will be shown and will be accompanied by screenshots of the EML-player Edubox.

In order to publish, deliver and test EML a system (Edubox) was designed and developed, in which EML-files can be imported and published in a personalised way to several media (http://www.ou.nl/edubox). Edubox has currently been developed to the stage that it can import, publish and deliver EML-files to the world-wide-web.

## 5.1 Roles

The first step in preparing a design for EML is to specify who plays a role in the instructional design. A separation in this respect has been made between student roles and staff roles (eg tutor, instructor, or teacher). The latter represents the educational organisation or institute (see figure 3). Which roles are present in the EML-design depends on the chosen pedagogical model.

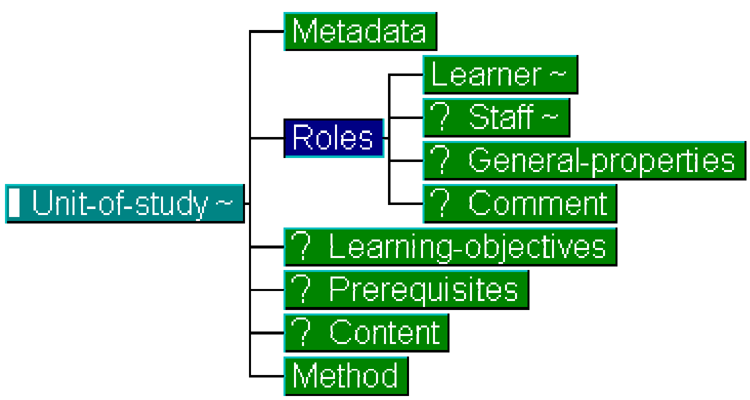



Figure 3: Role specification within EML (This a draft figure, the final figure will be provided)

EML-example 1 shows a role declaration within EML. This example has been derived from a problem based learning model.  It states that besides the role student there is specific sub role ‘chair’, who has specific responsibilities within this model. Besides these two student roles there is also a staff role named ‘tutor’.

```

<Roles>
    <Learner Id = "Student">
        <Role Id = "Chair"/>
    </Learner>
    <Staff Id = "Tutor"/>
</Roles>
```

EML-example 1: role declaration

## 5.2 Activities

The second step in the design is to specify what persons in these roles are expected to do. In EML this is referred to as ‘Activities’. There are two types of activities: learning activities, to be performed by student roles, and support activities, to be conducted by either staff or student roles. For example, in the case of peer assessment these support activities are typically reserved for students.
The EML-design the of the learning activities depends on the pedagogical model and can take the form of analysing problems, attending college, searching literature, present findings or take tests. Typical staff activities can consist of assessing students, providing feedback, monitoring, answering questions, etc.

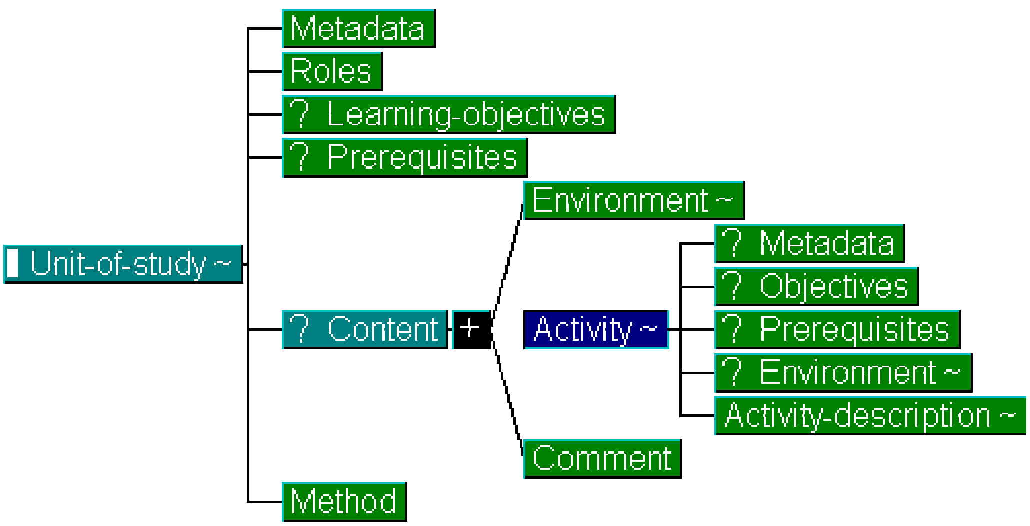



Figure 4: Activity specification within EML (This a draft figure, the final figure will be provided)

In EML-example 2 a learning activity has been elaborated briefly. Typical parts of a (learning) activity are the ‘Metadata’, the ‘Learning objectives’, the actual instruction (‘What’), a description of how the activity is to be carried out, and the condition under which an activity is to be considered completed. In this particular case, the completion is set to ‘User-choice’ (line 23), meaning that the user can decide himself (eg by clicking a check box) when the activity is completed. Completion rules play an essential part in workflow modelling. By stating explicit rules the workflow within a course or curriculum can be supported of fully handled by the EML-player.

```
1
2    <Activity Id = "a-conflict">
3        <Metadata>
4            <Title>Identifying an intercultural conflict on the workplace.</Title>
5        </Metadata>
6        <Learning-objectives>
7            <Learning-objective Id = “LO-1">
8                <Objective-description>
9                        <P>After completing this activity you are able to describe and
10                       analyse a conflict situation.</P>
11               </Objective-description>
12               <Objective-type><Skill></Objective-type>
```

```
13          </Learning-objective>
14        </Learning-objectives>
15        <Activity-description>
16          <What>
17            <P>In order to have sufficient and realistic material to analyse, you
18            will first need to …</P>
19          </What>
20          <How>
21            <P>Describe the conflict at surface level, ie...</P>
22          </How>
23        </Activity-description>
24        <Completed><User-choice/></Completed>
25      </Activity>
```

EML-example 2: activity specification

In example 2 lines 5-13 show that there is only one learning objective present for this learning activity, which has been typed as skill. Instead of stating the learning objective at this position, there also could have been made a reference to one or more learning objectives stated elsewhere for example at course level.

## 5.3 Environment

As was stated in paragraph 4.1, a learning activity is not to be performed in a vacuum, but takes place in a specific setting or context. This setting or context is generally referred to as the environment (see figure 5) of a learning activity. So a next step is to indicate which sources, tools and services an environment may consist of in order to support the student and or staff. Sources may consist of incorporated or external (linked) learning material like books, articles, cases, or references. Tools and services cover objects like search engines, glossaries, portfolios, notes, e-mail, or computer conferences.

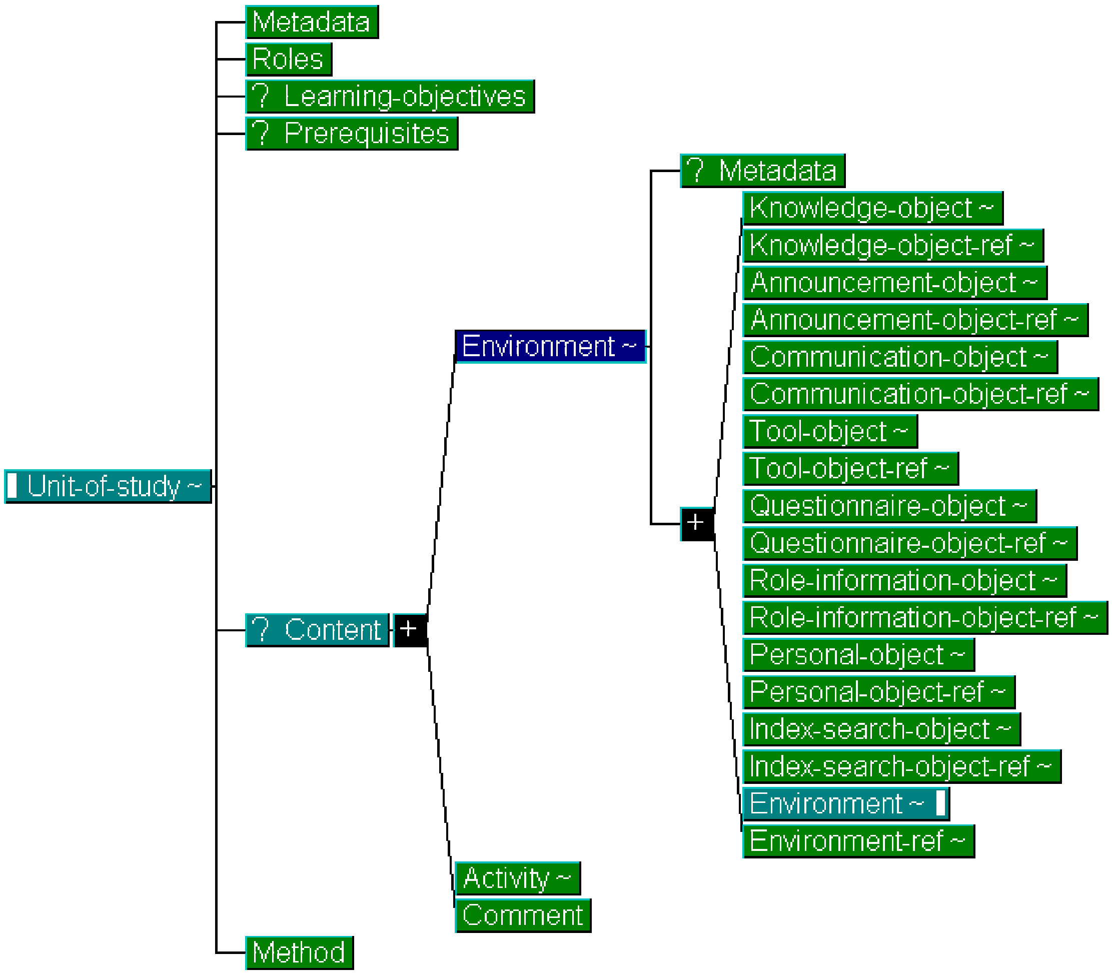



Figure 5: Environment specification within EML (This a draft figure, the final figure will be provided)

EML-example 3 provides an environment specification. Note that environments can be recursive, meaning that one environment can occur in another. In this way environment trees can be build and environment objects can be classified. The ‘Environment-ref’ element indicates that other environments are included. These environments and belonging objects may have been defined by others.

```
<Environment Link-name = “support environment”>
    <Environment-ref  Id-ref = "env-curriculum-guide"/>
    <Environment Link-name = “module guide”>
        < Knowledge-object  Link-name = “about this module”/>
        < Knowledge-object  Link-name = “method”/>
        < Knowledge-object  Link-name = “timetable”/>
    </Environment>
    <Environment Link-name = “communication”>
        <Communication-object  Link-name = “FirstClass”/>
    </Environment>
    <Environment-ref  Id-ref = "env-who-is-who"/>
    <Environment-ref  Id-ref = "env-resources"/>
    <Environment Link-name = “dossier”>
        <Role-information-object  Link-name = “progress”/>
```

```
    </Environment>
</Environment>
```

EML-example 3: environment specification in EML

A possible rendering of this environment specification by the Edubox system is shown in figure 6. The pane at the left provides several nodes representing the environment structure in EML. These nodes can collapse or expand by the user by clicking on the triangle. The leaf nodes represent particular learning objects, tools or services.

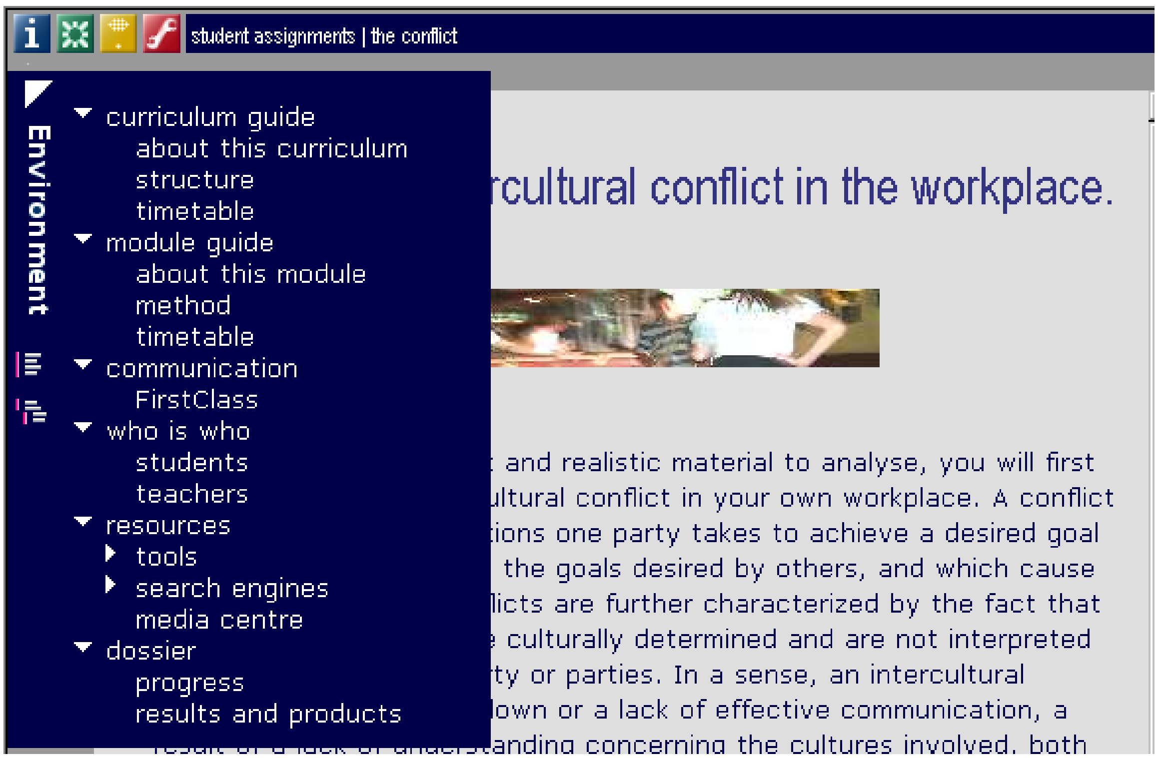



Figure 6: Environment representation in Edubox (This a draft figure, the final figure will be provided)

## 5.4 Method

Specifying the roles, activities and environments are the building blocks for creating one or more learning paths throughout a course or curriculum. The next step is to specify how (learning) activities are related, what the learning path looks like and how it can be influenced. The “Method” section (see figure 5) of EML had been designed for these purposes.

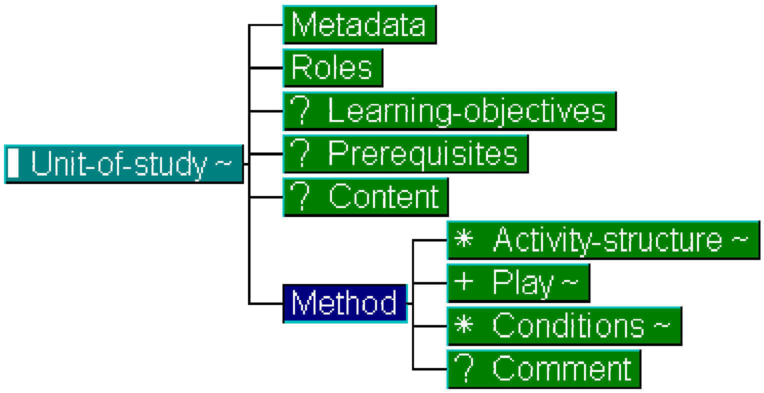



Figure 7: Method specification within EML (This a draft figure, the final figure will be provided)

First, possible relations between activities can be defined within ‘Activity-structures’. Within these structures activities can be grouped and put either in a fixed (‘Sequence’) or free order (‘Selection’). EML-example 4 provides an activity structure with a fixed order, named "Student tasks". This structure contains five learning activities (lines 5-10), which are to be performed sequentially. The representation of this example in Edubox is shown in figure 8. Note that as a consequence of modelling a sequence, an activity only becomes accessible when the preceding activity has been completed. This is an example of how workflow can be modelled.

```
1   <Method>
2       <Activity-structure Id = "AS-student">
3           <Activity-sequence Link-name = "Student tasks">
4               <Environment-ref  Id-ref = "Support-environment"/>
5               <Activity-ref Id-ref = "A-Introduction">
6               <Activity-ref Id-ref = "A-Conflict">
7               <Activity-ref Id-ref = "A-Theory">
8               <Activity-ref Id-ref = "A-Analysis">
9               <Activity-ref Id-ref = "A-Memo">
10          </Activity-sequence>
11      </Activity-structure>
12  </Method>
```

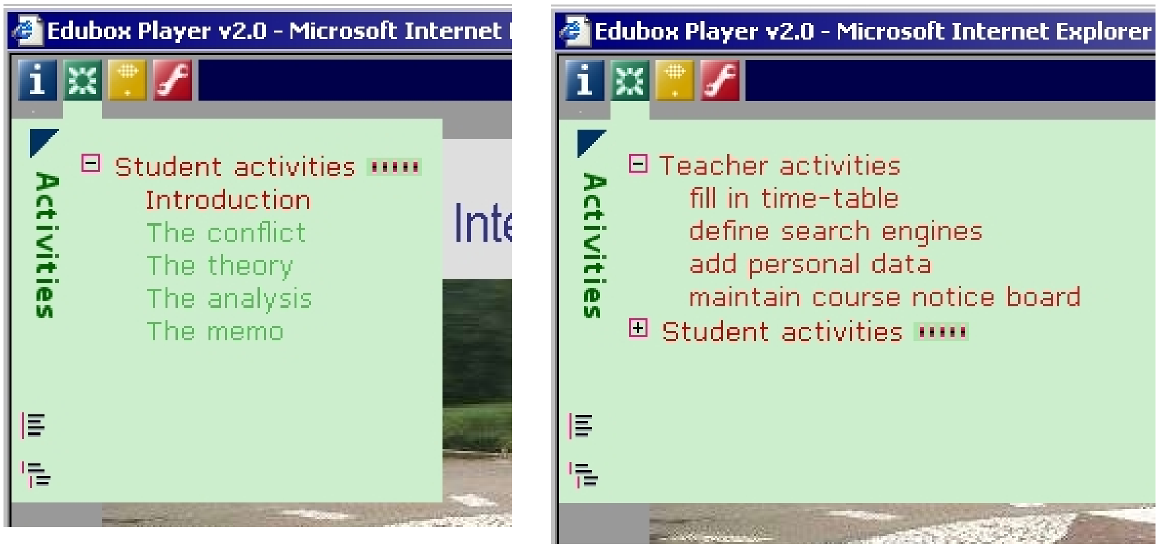
EML-example 4: sequencing example within EML


Figure 8: sequencing example in Edubox (This a draft figure, the final figure will be provided)

Second the educational script or scenario throughout eg a course or curriculum should be specified in the Play section of an EML-file. In this section, activities, activity structures, or complete units of learning can be assigned to specified roles.
EML-example 5 provides a simple example, in which two separate activity structures are assigned to two different roles (Student and Teacher). This means that in run time teachers and students get their own set of activities. Figure 9 provides the corresponding views in Edubox.

```
<Method>
   <Play Id = " Default-play">
      <Role-ref Id-ref = “Student”/>
      <Activity-structure-ref Id-ref = “AS-student”/>
      <Role-ref Id-ref = “Teacher”/>
      <Activity-structure-ref Id-ref = “AS-teacher”/>
   </Play>
</Method>
```

EML-example 5: Play example within EML




*Student view* *Teacher view*

Figure 9: play example in Edubox (This a draft figure, the final figure will be provided)

The third part of the method section of an EML-file (‘Conditions’) can be used to specify how (parts of) the learning path can be manipulated and adapted (personalised) to students’ characteristics. EML-example 6 is derived from a problem-solving model in which there is a specific student role called ‘Chair’. Persons in this role are supposed to perform specific activities (line 8) while working in groups and are provided with additional information within several learning objects, which has been typed or characterised as “only-for-chair” (line 7).

```
1    <Method>
2       <Conditions Id = "Chair-conditions">
3          <If>
4             <Is><Role-ref Id-ref = "Chair"/></Is>
5          </If>
6          <Then>
7             <Show><Content-type Type = "only-for-chair"/>
8             <Activity-structure-ref Id-ref="AS-chair"/></Show>
9          </Then>
10         <Else>
11            <Hide><Content-type Type = "only-for-chair"/>
12            <Activity-structure-ref Id-ref="AS-chair"/></Hide>
13         </Else>
14      </Conditions>
15   </Method>
```

EML-example 6: Conditions example within EML

## 5.5 Curriculum

Prior in this chapter a unit of study was presented as the smallest building block to assemble e.g. a curriculum or a course. The way these units of study are connected, are expressed in ‘Method’.

```
<Unit-of-study Id = “sample-curriculum”>
  <Metadata><Title><P>Sample curriculum</P><Title><Metadata>
  <Roles><Learner Id = “Student”></Roles>
  < Method>
      <Activity-structure Id = “Course-structure”>
          <Activity-selection Number-to-select = “3”>
            <Unit-of-study-ref Worldwide-unique-id-ref = “UoS-Course-1”/>
            <Unit-of-study-ref Worldwide-unique-id-ref = “UoS-Course-2”/>
            <Unit-of-study-ref Worldwide-unique-id-ref = “UoS-Course-3”/>
          </Activity-selection>
      </ Activity-structure >
      <Play>
            <Role-ref Id-ref = “Student”>
            <Unit-of-study-ref Worldwide-unique-id-ref = “UoS-PostAssessment”/>
            <Continue><When-completed/></Continue>
            <Role-ref Id-ref = “Student”>
            <Activity-structure-ref Id-ref = “Course-structure”>
            <Continue><When-completed/></Continue>
            <Role-ref Id-ref = “Student”>
            <Unit-of-study-ref Worldwide-unique-id-ref = “UoS-PostAssessment”/>
      </Play>
  </Method>
</Unit-of-study>
```

EML-example 7: Modelling a curriculum or programme within EML

Lines 13-20 of EML-example 7 show the learning path throughout a simple curriculum. A student starts with a pre assessment, which can be of any kind. Having finished this assessment, the student may continue by choosing one of three specific courses. These courses are wrapped in an ‘Activity-structure’. Adding an ‘Activity-selection’ provides the student the freedom to choose which course to start. The ‘Number-to-select’ attribute in line 6 puts a completion constraint on this structure. The student must have completed all three courses before he can march to the next part, in this case a post-assessment.

## 6. EVALUATION

Of course, the proof of the pudding is in the eating. The requirements stated earlier in this chapter, and the pedagogical meta model have resulted in the EML version as described and illustrated in the preceding paragraphs. Let’s review how the major requirements have been met in this version of EML.

It may be clear from the examples that EML succeeds in designing a formalised language (requirement 1) for expressing an educational design with a focus on semantics rather than on technical aspects (requirement 3). The fact that the run time system Edubox is able to interpret various EML-files and to deliver the content in a personalised manner to users in concrete educational settings, supports this statement. Furthermore, the choice to develop EML as an application of XML meets demands like interoperability, compatibility, and medium neutrality.

Of particular interest is to which extend EML appears to be suitable for expressing divergent pedagogical models (requirement 2). After performing some laboratory tests with EML several implementations have been realised successfully in a variety of educational settings in the last two years.

One major implementation is situated within the area of higher vocational education. For an institute for Hotel management a translation of their pedagogical model of dual mode competency based learning was made in EML. Almost all the modules within this dual mode curriculum have been elaborated in EML and are delivered to their students using Edubox system. EML concepts like ‘Activity’ and ‘Environment’ appeared to be strong and useful concepts for modelling tasks and support tools and resources corresponding to the designers’ intentions.

At university level, EML is being tested within our own institute as well as within the context of the Digital University (DU, consortium of four universities and six institutes for higher vocational education). Within the DU institutes are working together to create reusable learning materials. Most of these institutes have their ‘own’ e-learning environments. As a result there is a strong focus upon interoperability, reusability and use of open standards with respect to the learning material. EML appears to be well suited in this respect.

Within the OUNL itself, a number of pilot projects have been initiated within several faculties. The institute renewed its pedagogical model to competency based learning in an electronic learning environment (Koper, 2000). Several courses with different instructional designs have been implemented in EML. .

Another application area can be found within the field of in company training. For a major pension fund a renewed model for the training of call centre employees has been translated and elaborated using EML. Also in this context, EML proved to be a powerful instrument within an innovation process.

Finally EML proved to be interoperable and sustainable as work on the EML specification evolved (see next section). It was possible to design and implement automated translation routines, allowing the 'upgrade' of existing EML materials. Al large number of the courses produced using EML are already successfully being converted, safeguarding all the investments made in producing the courses.

## 7. THE WAY AHEAD

In the previous paragraphs EML and its requirements were described in detail. There is a lot of experience gained using EML in an increasing number of courses and settings. Although in principle this satisfies the whish to have a specification that is pedagogical flexible and interoperable, the latter is only true for the scope of our institute and same of our partners closely involved in the development of the EML.

Looking critically at the definition of interoperability (the ability of a system or a product to work with other systems or products without special effort on the part of the customer) one can conclude that true interoperability can only be achieved if the following criteria are met:

- A specification should be publicly endorsed by the key players in the field, like education content providers (publishers etc), providers of e-learning environments and the educational community in general. By this endorsement all key players basically commit themselves to the specification;
- E-learning environment providers should have native support for the specification in their products, guaranteeing interoperability between the different e-learning environments;
- A specification should support standards and other specifications that are generally accepted.

There are a number of ways to achieve the criteria mentioned above. It was decided that the best way to proceed with EML was to get the specification accepted by a group of key players (end users, vendors, purchasers and managers) therewith creating a de facto standard. Formal standardisation would then be the secondary and final long-term aim.

Big advantage of the chosen approach is the fact that results can be achieved in a relative short period of time. An important group of key players with sufficient influence are organised in the IMS Global Learning Consortium.
IMS has a working group concerning the topic of Learning Design. In a close cooperation with other parties involved, EML was chosen as basis for the IMS Learning Design specification. Using EML as a base did not imply that nothing would change. The major difference between EML and the IMS Learning Design specification is the integration of existing IMS specifications into the new specification. However at conceptual level there are no differences between EML and the Learning Design specification (2002).

At this moment the IMS Learning Design specification has reached the status of a final specification and is available from http://imsglobal.org.

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