Educational modelling language

Citation for published version (APA):

Koper, R., & Manderveld, J. (2004). Educational modelling language: modelling reusable, interoperable, rich and personalised units of learning. *British Journal of Educational Technology*, *35*(5), 537-551. https://doi.org/10.1111/j.0007-1013.2004.00412.x

DOI:
10.1111/j.0007-1013.2004.00412.x

Document status and date:
Published: 01/09/2004

Document Version:
Early version, also known as pre-print

Please check the document version of this publication:

• A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
• The final author version and the galley proof are versions of the publication after peer review.
• The final published version features the final layout of the paper including the volume, issue and page numbers.

Link to publication

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

• Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
• You may not further distribute the material or use it for any profit-making activity or commercial gain
• You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the “Taverne” license above, please follow below link for the End User Agreement:

https://www.ou.nl/taverne-agreement

Take down policy
If you believe that this document breaches copyright please contact us at:

pure-support@ou.nl

providing details and we will investigate your claim.

Downloaded from https://research.ou.nl/ on date: 06 May. 2021

Open Universiteit
www.ou.nl

Educational Modelling Language
Modelling reusable, interoperable, rich and personalised units of learning

Rob Koper and Jocelyn Manderveld[1]

ABSTRACT

Nowadays there is a huge demand for flexible, independent learning without the constraints of time and place. Various trends in the field of education and training are the bases for the development of new technologies for education. This article describes the development of a learning technology specification, which supports these new demands for learning challenging the new technological possibilities. This specification is named Educational Modelling Language (EML) and is developed by the Open University of the Netherlands.

Introduction

In this article a modelling approach for units of learning, called 'Educational modelling language' (EML) is described. A unit of learning is an artefact that is designed for learners to achieve one or more interrelated learning objectives. A unit of learning can not be broken down into its component parts without loosing its semantic and pragmatic meaning and its effectiveness towards the attainment of the learning objectives. In practice you see units of learning in all types, sorts and sizes: courses; study programs; workshops; practicals; lessons, etc. are all examples of units of learning. EML is defined as a semantically rich information model and binding, describing the content and process within units of learning from a pedagogical perspective in order to support reuse and interoperability (see Koper, 1991, 1998, 2000). To state it differently: EML is a semantic notation for units of learning to be used in e-learning. The modelling is done with use of the Unified Modelling Language, UML (Booch *et al,* 1999) and the binding is in an XML schema.

The ideas underlying EML are derived from various trends in the field of education and training, such as life long learning, globalisation and possibilities offered by new technologies. There is a worldwide need for continuous access to knowledge and a need for assessment and accreditation of competences related to employability, whether obtained formally or informally. The borders between learning, work, leisure and home-activities are diminishing. New technologies provide the means to integrate teaching and training facilities into every aspect of life. This constitutes a need for open, flexible, opportunities for learning and assessment, independent of time and place.

Traditional institutes of education and training are developing ways to provide more flexible access to education and training. This will result into a transformation of institutes formerly offering single mode education, and now or in the future offering a mix of delivery modes:

[1] To Be Published in: British Journal of Educational Technology (2004). Please refer to the printed version of the article. Rob Koper and Jocelyn Manderveld are at the Educational Technology Expertise Centre of the Open University of the Netherlands. Address for correspondence: Jocelyn Manderveld, Open University of the Netherlands, PO Box 2960, NL-6401DL, Heerlen, The Netherlands. Email address jocelyn.manderveld@ou.nl

classroom teaching and training, part-time teaching, distance teaching, distributed education and virtual universities for continuing education (Lewis *et al,* 1999).
In order to provide flexible learning, institutions face the problem of redefinition of their mission in terms of the pedagogical principles, organisation and infrastructure. Internet facilities provide a means to redefine the course delivery and instructional methods.

At the *pedagogical level,* institutes are faced with new paradigms of teaching and learning, which have been established in order to make education more effective. Examples are competency based learning (Schlusmans *et al,* 1999; Spencer *et al*, 1993), collaborative learning (Dillenbourg *et al*, 1995), case based learning (Leenders *et al*, 1989) and performance improvement approaches (Robinson *et al*, 1995). Most of the new approaches are based on constructivist principles (Brown *et al*, 1989). They are applied, both purely and mixed, to the older directed instruction formats (Roblyer *et al*, 1999). All these developments in the field define new requirements for learning and the instructional design of units of learning. The focus is on the following concepts (also see Wilson *et al*, 1995; McLoughlin *et al*, 1999; Reigeluth, 1999):

- Learning is an active, constructive, cumulative and goal-directed process (Shuell, 1988),
- Education and training is learner centred, learners may define their own learning objectives and monitor and regulate their own learning process (Kinzie, 1990; Gall *et al*, 1994),
- Individual characteristics of learners are taken into account,
- Flexibility for learners is offered in terms of flexibility in time, place and media used,
- Resources are distributed and are widely and easily accessible through the Internet,
- The teacher and trainer is a facilitator and a coach (Wood *et al*, 1996),
- Learning is not an isolated act, but embedded in a social context, principles of collaborative learning are applied.
- Assessment and tasks are more product driven, instead of knowledge driven,
- There is an emphasis on alternative assessment methods, such as peer assessment, portfolio assessment and tests with open ended questions.

The new principles define new roles and new activities for learners and staff. In order to support these roles and activities, learning environments need to be *rich* environments (Scott Grabinger, 1996; Manderveld *et al*, 1999; Koper, 2001a), available anytime, everywhere and - because of efficiency and attractiveness - need to be flexible and adaptive. Flexible in terms of time, place, content, sequence and delivery media and adaptive in terms of matching the characteristics of all the persons using it, not only for learners, but also for staff members.

At the *technological level*, institutes are faced with large investments in infrastructure and the problem of rapidly changing technology. Especially when course development and delivery are integrated into technology, the problem arises that technological change leads to conversion and adaptation problems in the educational content and processes. Nowadays, a lot of courses are adapted or written for the web, or more specific: for a particular Learning Management System. The web has a lot of advantages, but also has its disadvantages when compared to other media and face to face meetings. Developing courses for a particular delivery format, such as the web, does not provide the flexibility needed for fully flexible, effective and efficient education.
This reasoning has led to the conclusion that we must focus on the development of medium neutral, interoperable units of learning instead of units of learning in a medium specific format.

In order to attain the objectives described above we started the project to develop EML in 1998. In the next paragraphs the focus is on the development of EML. Eventually, EML is presented along with an example of its use.

Development of EML

The development process of EML consisted of separate iterations of analysis, design, implementation, test and evaluation. The complete development process of EML took about three years and was conducted by a large variety of experts such as educational technologist. ICT-experts, XML-experts etc. In this section the method of development is described.

Analysis
In this first phase a definition study was conducted by a group of educational technologists and ICT-experts, who defined the requirements for EML. The requirements for the design of EML were the following:

A. General requirements
- EML should describe a model for a unit of learning.
- EML should describe units of learning in a formal way, so that automatic processing is possible. This includes: editing, storage, assembly and delivery.
- EML should use an interoperable notation for units of learning. Through this, investments in educational development will become resistant to technical changes and conversion problems.
- EML should describe the units of learning so that repeated execution is possible. This means that EML should model artefacts that are designed and developed in advance and not the artefacts that are produced in runtime.
- EML should model all the content resources and communication services, which are present in the unit of learning.
- EML should not describe the actual 'run' of a unit of learning for actual learners at a given time, but instead it must describe the general case which can be instantiated as many times as necessary for different learners at different times.
- EML should allow to package a unit of learning in one container or file to enable transportation. However, it must also be possible to break the container down to its subcomponents or to edit subcomponents and integrate them into an unit of learning by reference.
- EML should describe metadata for the unit of learning and all of its reusable sub artefacts in order to identify the characteristics and ownership, to support search, reference and assembly.
- EML should be built on available standards and specifications where possible. This includes specifications from IMS (http://www.imsproject.org), IEEE LTSC (http://www.ltsc.ieee.org/), ISO/IEC JTC1/SC36 (http://jtc1sc36.org/), IACC (http://www.aicc.org), and ADL SCORM (http://www.adlnet.org) .
- EML should make it possible to produce, mutate, preserve, distribute and archive units of learning and all of its containing learning artefacts.

B. Instructional design requirements for units of learning
- EML should 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. Regardless of whether these aspects are represented digitally or non-digitally.
- EML should define the conditions under which different learning artefacts can be aggregated into a valid unit of learning.
- EML should explicitly express the semantic meaning of the different learning artefacts within a unit of learning, using a pedagogical vocabulary from the educational domain.
- EML should allow users to map the pedagogical terminology used in EML to their own terminology.

- EML should allow to model different kinds of pedagogical models, including the more traditional teacher directed and information transmission based models, as well as the more student centred, collaborative and constructivist approaches.
- EML should make a distinction in different roles, especially learner and staff roles. However it should not be rigid in allowing certain kinds of activities only for certain roles. One must be able to assign all kinds of activities to staff as well as to learner roles in order to be able to shift learning functions from the one to the other (Shuell, 1988, 1996, Koper, 1995).
- EML should enable to define formal criteria for a student to be met in order to complete (parts of) a unit of learning. This means that assessment procedures and tools, along with other completion facilities must be available. In this respect, classical testing such as multiple-choice testing, as well as new assessment models such as performance tests or portfolio assessment should be supported (Hambleton, 1996; Sluijsmans, 2002).
- EML should be able to describe personalisation 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.
- EML should be able to use and define properties in a learner dossier, in order to build portfolios, support monitoring facilities and support student tracking.
- EML should allow units of learning to contain other units of learning. This allows to build a curriculum (a unit of learning) from underlying courses (a unit of learning) which itself can consist of different units of learning (e.g. a lesson).

In the analysis stage also a vocabulary and preliminary models and architectures for EML were defined.

Design
Based upon the analysis of EML the first draft design of EML was made. A group of eleven designers was selected with expertise in different areas: distance education, competency based training, use of multimedia and ICT in education, use of traditional educational media and XML/SGML expertise. This group analysed the structure of the educational components within units of learning for new and existing approaches to learning and instruction. This group also defined the basics of the process of personalisation.

Another group of experts defined the structure of the XML application; decided upon the implementation of the XML application in terms of one or more XML schemas or DTDs; selected the standards to be used and followed as sub standards related to XML, such as link standards, file format standards, character standards. Last but not least they studied XML and SGML applications, such as the Dublin Core for metadata, Tutorial Markup Language (http://www.ilrt.bris.ac.uk/netquest/about/lang/motivation.html), IMS (http://www. imsproject.org), Ariadne (Forte *et al*, 1997), The Workflow Management Coalition (http://www.wfmc.org/), AICC (http://www.aicc.org), OASIS applications (http://www.oasis-open.org).

Implementation
The requirements for EML and the design were leading for the implementation. Several versions of EML were implemented and evaluated, before version 1.0 was released. All the previous versions and the EML 1.0 version were tested in several courses and curricula (within and outside the OUNL). This iterative implementation and testing phase resulted in four versions of EML.

The first test implementation of EML (EML 0.1) followed the design mentioned above. However, considering the requirements the resulting DTD was found to be too complex and containing elements only for the modelling of competency based learning.
In order to make EML more generic, a new analysis was conducted. The idea was to define a pedagogical meta model, which was neutral to the different approaches to learning and

instruction, and then take the entities of the meta model as a starting point for modelling EML. This meta model is based on principles of system methodology (Checkland, 1999) and the literature on learning and instruction and instructional design theories (e.g. Reigeluth, 1987, 1999; Stolovitch *et al,* 1999). This resulted in the second implementation of EML 0.5. A new version of EML was developed on the basis of the evaluation results of the EML 0.5 version. This version was called 0.9. Lots of pilot implementations have been done with this version. To mention two large-scale projects: within the OUNL a pilot project was set up to test this version, along with its interpreting software. Outside the OUNL a whole year curriculum was modelled and exploited in this version. About two hundred, mostly very small, changes to EML came from this process. After the test period of the version 0.9 the diagnosis was that the adapted version of EML was stable enough to release it in the public domain as EML 1.0.

In the next paragraph the structure of EML and the models behind EML will be described.

EML 1.0

The result of the development process was the release of EML 1.0. As written above the focus in this paragraph is on the models behind EML and the structure of EML. The Reference Manual, which provides a full description of all the elements and attributes within EML and the DTD as well, can be downloaded at http://eml.ou.nl.

In this paragraph we make a distinction between:
- The pedagogical meta model behind EML
- The unit of learning model
- Basic structure of EML

Pedagogical meta model

During the development of EML a pedagogical meta model emerged, which is the base for EML. A pedagogical meta model is a model which models pedagogical models. This means that pedagogical models could be described (or derived) in terms of the meta model. The pedagogical meta model is based upon educational research, specially in the field of learning psychology and instructional design (see Koper, 2001b).

This educational research resulted in the five axioms of the pedagogical meta model:
1. A person learns by performing goal directed activities in an environment
2. When a person has learned, he is able (a) to perform new activities or perform activities better or faster in similar environments or (b) to perform the same activities in different environments
3. An environment consists of a set of objects and/or human beings that are related in a particular way.
4. A person can be encouraged to perform certain activities when:
    a. The activities can be performed by this person, given the requirements in terms of pre-knowledge, personal circumstances and the performance context.
    b. The required environment is made available.
    c. The person is motivated to perform the activities.
5. What had been posed here with respect to a single person, also applies to a group of persons.

These axioms refer to the way people learn but still nothing has been said about the actual instruction. In this respect instruction has been defined as follows: 'Instruction is a process which aims at accomplishing and measuring learning results".

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. Assessment of what has been learnt may consist of providing students with specific activities, which enable them to show that the aimed learning objectives have been obtained.

Unit of learning model

Based upon the pedagogical meta model the unit of learning model was derived.

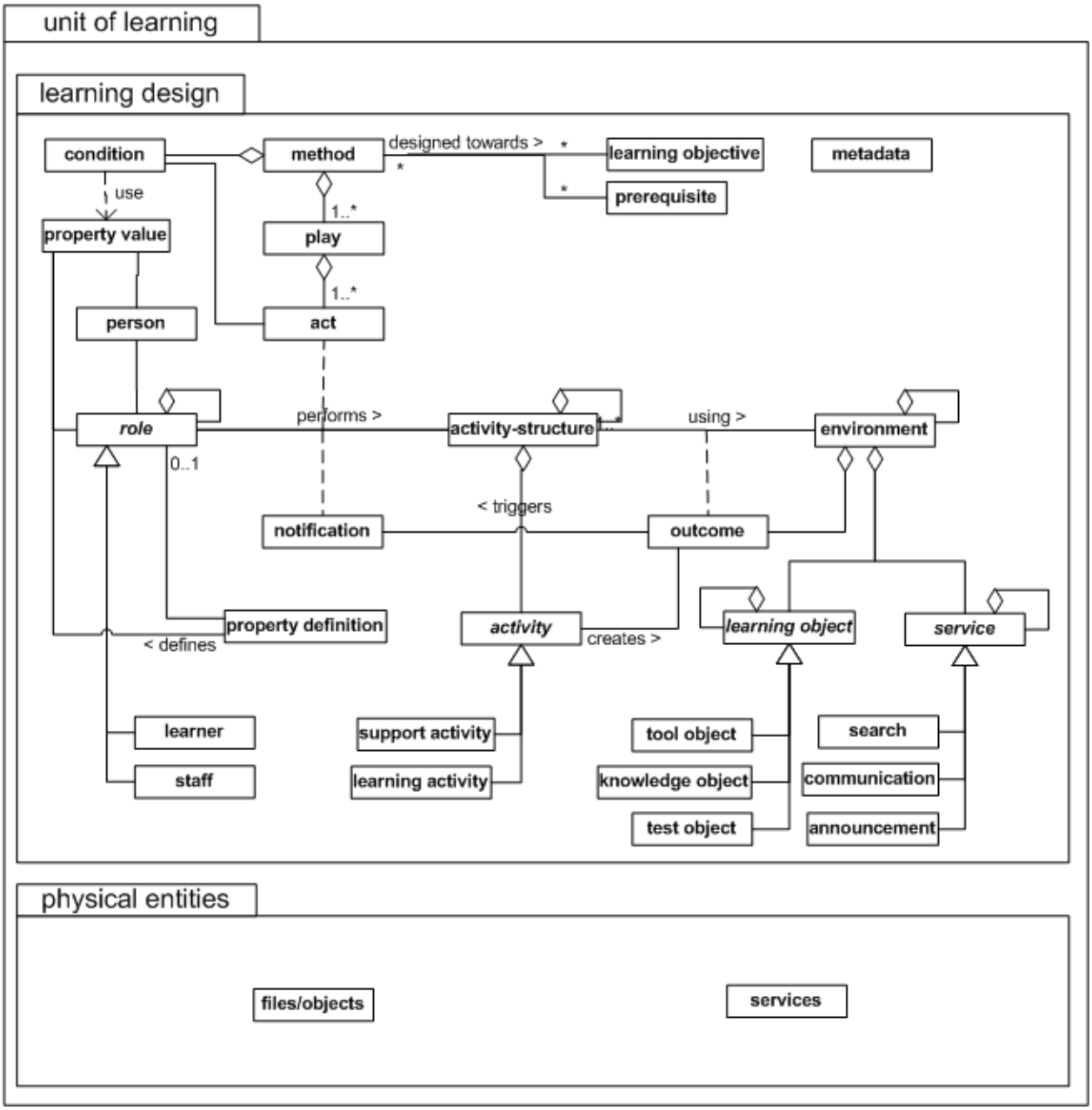

Figure 1. Semantic information model of a unit of learning, expressed in UML

The core concept of the unit of learning model, as expressed in figure 1, is that, regardless of pedagogical approach, a *person* gets a *role* in the teaching-learning process, typically a

learner or a *staff* role. In this role he or she works towards certain *outcomes* by performing more or less structured *learning* and/or *support activities* within an *environment*. The environment consists of the appropriate *learning objects and services* to be used during the performance of the activities. Which role gets which activities at what moment in the process, is determined by the *method* or by a *notification*.

The *method* is designed to meet *learning objectives*, and presupposes certain *prerequisite*. The method consists of one or more concurrent *play*(s); a play consists of one or more sequential *act*(s). A method may contain *conditions*, ie If-Then-Else rules that further refine the visibility of activities and environment entities for persons and roles, by defining Boolean expressions on their *properties*. A *notification* is triggered by an outcome and can make a new activity available for a role to perform.

Activities can be assembled into *activity-structures*. A structure can model a sequence or a selection of activities. In a *sequence*, a role has to complete the different activities in the structure in the order provided. In a *selection*, a role may select a given number of activities from the set provided in the activity-structure.

Environments can contain two basic types:

1. Located *learning objects* In EML the learning objects are classified in the following types: knowledge-objects, tool-objects and test-objects.
2. *Services*. A service relates to a concrete service facility available at runtime. Examples of a Service include a discussion forum, chat rooms, monitoring tools, search facilities, etcetera.

Basic structure of the EML-binding

The unit of learning information model is implemented in an XML DTD binding. The complete EML binding contains more than 100 elements and can be found at http://eml.ou.nl. The basic structure of EML is shown in a tree view in figure 2. Only a selection of the elements is shown and no attributes are shown.

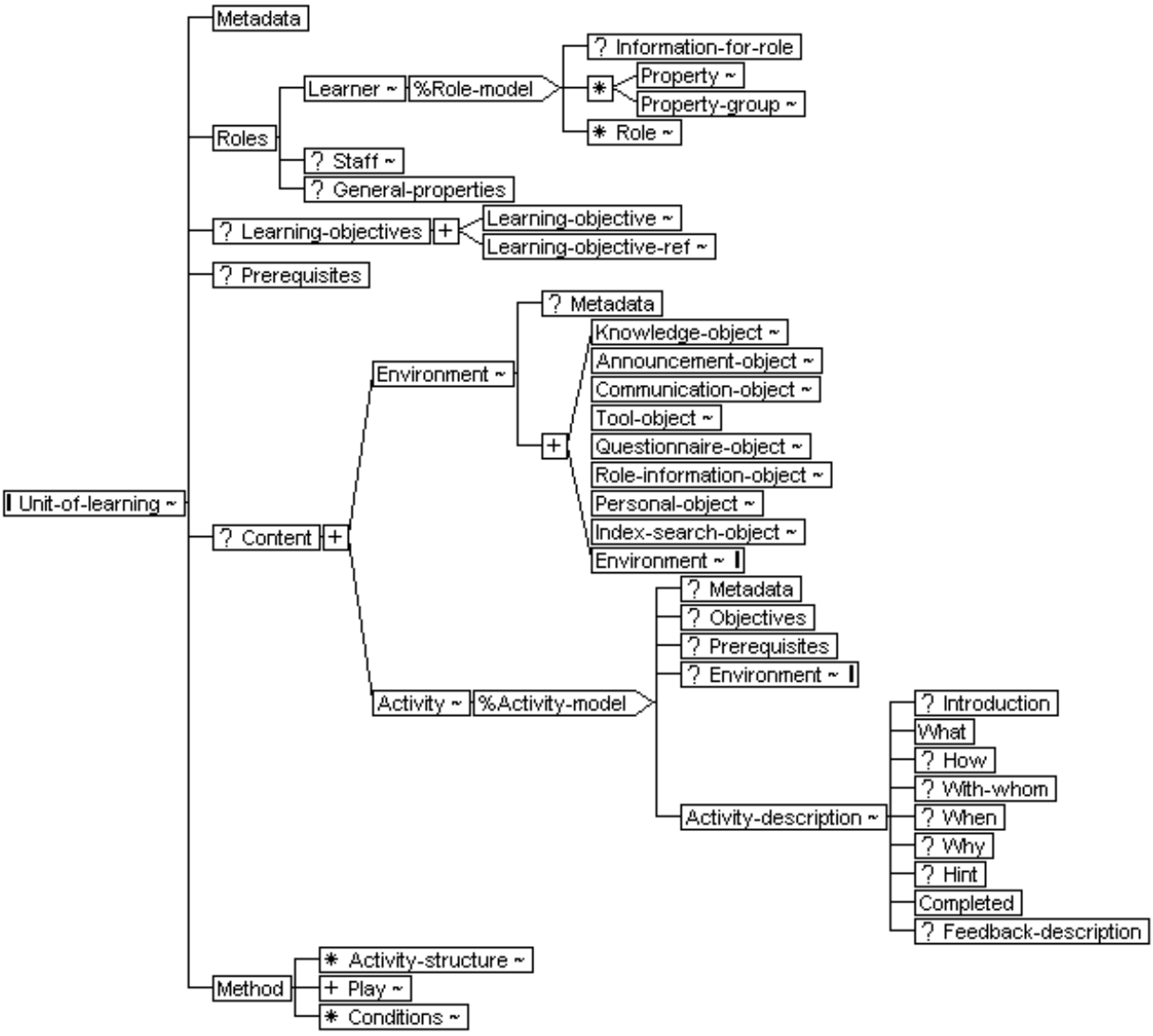

Figure 2: Basic structure of EML

An example of the use of EML is presented in figure 3.

```
<Unit-of-learning Type="Course">
  <Metadata><Title>Educational modelling language</Title></Metadata>
  <Roles><Learner Id="Student"/>
          <Property Id="Show example"><String/></Property>
        </Learner>
  </Roles>
  <Learning-objectives>
      <Learning-objective><Objective-description> Gather insight in EML<\Objective-description>
        <Objective-type><Insight/></Objective-type>
      </Learning-objective>
  </Learning-objectives>
  <Content>
      <Activity Id="Preparation" >
        <What>
            <P> Student receives information on course </P>
            <Interactions>
              <Prompt>
                <Question><P> Do you want to study with or without examples?</P></Question>
                <Choice Id="1"><P>Yes</P></Choice>
                <Choice Id="2"><P>No</P></Choice>
                <When-choice Id-ref="1">
                  <Change property-value>
                    <Property-ref Id-ref="Show-example"/>
                <Property-value>Yes</Property-value>
                  </Change-property-value>
                </When-choice>
              </Prompt>
            </Interactions>
        </What>
        <Completed><When-property-value-is-set><Property-ref Id-ref="Show-Example"/></When-
        property-value-is-set></Completed>
      </Activity>
      <Activity Id= "Assignment 1">
        <Environment>
            <Knowledge-object Id="Article">
                <Metadata><Title>EML: Modelling re-usable, interoperable, rich and personalised
                units of learning</Title>
            </Metadata>
                <Source><P>This is the text of this article </P> <Special Content-type="CT-
                example"><P> The example of this article is represented here</P></Special>
                </Source>
            </Knowledge-object>
        </Environment>
        <What><P> Read the article on EML. </P></What>
        <Completed><User-choice/></Completed>
      </Activity>
      <Activity Id= "Assignment 2">
        <What><P> Look at the website of EML and describe what EML is and how it was developed.
        </P></What>
        <Completed><User-choice/></Completed>
      </Activity>
  </Content>
  <Method>
      <Play>
        <Role-ref Id-ref="Student"/><Activity-ref Id-ref="Preparation"/>
        <Role-ref Id-ref="Student"/><Activity-ref Id-ref="Assignment 1"/>
        <Role-ref Id-ref="Student"/><Activity-ref Id-ref="Assignment 2"/>
      </Play>
      <Conditions>
        <If><Is><Property-ref Id-ref="Show-example"/><Value> <String>Yes</String>
        </Value></Is></If>
        <Then><Show><Content-type><Type Content-type="CT-example"/></Content
        type></Show></Then>
      </Conditions>
  </Method>
</Unit-of-learning>
```

Figure 3: Example of EML

This example represents a small course modelled in EML. It shows a couple of learning activities, which a student needs to perform in order to meet the learning objectives of the course. There is some personalisation in this example. The student can choose between studying with or without examples. This course is representing one of the possible didactical models in EML. But it could have been a module based upon problem based learning or competency based learning. EML is based upon an pedagogical meta model, so most known and common pedagogical designs can be implemented in EML. All XML-elements are between brackets. There is always a start tag (<…>) and an end tag (</…>). All content is specified between the start and end tags. In the example the XML-tags are marked as bold.

Conclusions and further developments

The aim of the development of EML was to define a semantically rich information model and binding, describing the content and process within units of learning from a pedagogical perspective in order to support reuse and interoperability. This model had to support the demands for open and flexible learning independent of time and place, the new paradigms of teaching and learning and the challenges at the technological level, especially the medium neutrality and interoperability of units of learning. The requirements for EML are based upon these demands. This raises the question whether EML 1.0 meet all the specified requirements?

In order the answer this question a lot of different tests were conducted with EML 1.0, for instance:

- A full 440-hour course delivered in mixed face to face and distance teaching mode was developed in EML and run with actual students (instead of the regular course which was provided before). This course was part of a curriculum of an institute for higher vocational education in the field of Hotel Management. The average number of students who attended the four presentations of this course was between fifty and sixty. Also a complete competency based curriculum was developed for dual mode education, consisting of six courses.
- Eight distance teaching courses in several fields, public administration, psychology, law, methodology, with thousands of pages of domain specific content in EML and a variety of instructional models (traditional and more competency based models as well) were developed and delivered to students of the Open University of the Netherlands.
- Several units of learning were developed for testing and demonstrating issues, dealing with the more complex constructs of EML, such as personalisation and workflow (learning flow) modelling.

All cases were evaluated. Students and staff completed questionnaires and were interviewed. Furthermore, several evaluation days were organised with the whole development team of EML. The central question of this evaluation was: Is it possible to model units of learning in EML, with a variety of pedagogical models, support of medium neutral delivery of the material and interoperability? (Verreck *et al*, 2001). The results of the large scale evaluations showed that it is possible to model units of learning in EML. EML 1.0 met all the specified requirements (stated in this article). The demands at a pedagogical and technical level for EML were all supported.

These positive results of the evaluation led to the decision that EML 1.0 should be available for the public, EML 1.0 was released at the end of 2000. In order to broaden the scale of use of EML we started to participate in different national and international standardisations efforts for learning technology specifications, as IMS (Instructional Management Systems), CEN/ISSS-WS-LT (European Committee for Standardisation- Information Society Standardization System-Workshop- Learning Technologies),and Prometeus (Promoting

Multimedia access to Education and Training in the European Society). We positioned EML in these bodies and this resulted in the following:

- EML 1.0 is the base for the IMS Learning Design specification, which is released in October 2002. The IMS-Learning Design public draft is available for public consultation at http://www.imsproject.org.
- EML is a chapter on the workplan of the CEN/ISSS-WS-LT. The definition of EML and the information model describing EML is accepted by the CEN.
- Prometeus is currently defining the issues for the specification of learning technology that will be presented for the European Commission's committee for the Sixth Framework programme. The ideas behind EML are described within Prometeus.

EML is nationally and internationally accepted as a modelling language for units of learning. The development of EML did not come to an end. We are still working on improving the model of EML and the development of new learning technology specifications that support the demands for flexible learning independent of time and place.

References

Booch G, Rumbaugh J and Jacobson I (1999) *The Unified Modeling Language User Guide* Reading, Addison-Wesley.

Brown J S, Collins A and Duguid P (1989) Situated Cognition and the Culture of Learning. Educational Researcher, 18 (1), 32-42.

Checkland P (1999) Systems Thinking, Systems Practice John Wiley & Sons, LTD,Chichester.

Dillenbourg P and Schneider D (1995) Mediating the mechanisms which make collaborative learning sometimes effective. International Journal of Educational Telecommunications, 1, 131-146.

Forte E, Wentland-Forte M and Duval E (1997) The ARIADNE project (part I and II): Knowledge Pools for Computer Based & Telematics Supported Classical, Open & Distance Education. European Journal of Engineering Education, 22 (1/2), 61-74 (part I) en 153-166 (part II).

Gall J E and Hannafin M J (1994) A framework for the study of hypertext. Instructional Science, 22, 207-232.

Hambleton R K (1996) Advances in assessment models, methods, and practices in Berliner D C and Calfee R C (eds.), Handbook of Educational Psychology (pp. 899-925.) Simon & Schuster Macmillan, New York.

Kinzie M B (1990) Requirements and benefits of interactive instruction: Learner control, self-regulation, and continuing motivation Educational Technology Research and Development, 38 1, 5-21.

Koper E J R (1991) Inscript: A courseware specification language. Computers & Education, 16 2, 185-196.

Koper E J R (1995) PROFIL: A method for the development of multimedia courseware. British Journal of Educational Technology, 26 2, 94-108.

Koper, E J R (1998) Definitiestudie Elektronische Leeromgeving Open Universiteit Nederland, Heerlen.

Koper, E J R (2000) From change to renewal: educational technology foundations of electronic learning environments (http://eml.ou.nl/introduction/docs/koper-inaugural-address.pdf)

Koper, E J R (2001a) Van verandering naar vernieuwing in Schramade P (ed) Handboek Effectief Opleiden, Delwel, 's Gravenhage.

Koper, E J R (2001b) Modeling Units of Study from a Pedagogical Perspective: the pedagogical meta model behind EML (http://eml.ou.nl/introduction/docs/ped-metamodel.pdf)

Leenders M R and Erskine J A (1989) Case research: the case writing process (3e ed) University of Western Ontario,Ontario.

Lewis L, Levin D and Greene B (1999) Distance education at postsecundary education institutions: 1997-98. Department of Education ,Jessup.
Manderveld J M and Koper E J R (1999) Building a competence based electronic learning environment in Collis B and Oliver R (eds) Ed-Media 1999: World conference on Educational Multimedia, Hypermedia & Telecommunnications (pp. 1543-1544) AACE, Charlottesville.
McLoughlin C and Oliver R (1999) Pedagogic roles and dynamics in telematics environments in Selinger M and Pearson J (eds) Telematics in education: Trends and issues (pp. 32-50.) Pergamon, Oxford.
Reigeluth Ch M (ed) (1987). Instructional theories in action Lauwrence Erlbaum Associates, Hillsdale, NJ: Lawrence Erlbaum Associates.
Reigeluth C M (1999) (ed) Instructional-design theories and models: A new paradigm of instructional theory Lawrence Erlbaum Associates,Mahwah.
Robinson D G and Robinson J C (1995) Performance consulting: Moving beyond training. Berrett-Koehler, San Francisco.
Roblyer M D and Edwards J (2000) Integrating educational technology into teaching (second edition) Merrill, Prentice Hall , Upper Saddle River.
Schlusmans K, Slotman R, Nagtegaal C and Kinkhorst G (1999) (eds) Competentiegerichte leeromgevingen (competence based learning environments) Lemma, Utrecht
Scott Grabinger R (1996) Rich environments for active learning in Jonassen D H (ed) Handbook of research for educational communications and technology (pp. 665-692.) Macmillan, New York.
Shuell Th J (1988) The role of the student in learning from instruction. Contemporary Educational Psychology, 13, 276-295.
Shuell Th J (1996) Teaching and learning in a classroom context in Berliner D C and Calfee R C (eds) Handbook of Educational Psychology (pp. 726-764.) Simon & Schuster Macmillan ,New York.
Sluijsmans, D (2002) Student involvement in assessment: the training of peer assessment skills [dissertation]. Heerlen: Open Universiteit Nederland.
Spencer L M and Spencer S M (1993) Competence at work: Models for superior performance John Wiley & Sons, Inc, New York.
Stolovitch H D and Keeps E J (1999) (eds) Handbook of human performance technology Jossey-Bass Publishers,San Francisco.
Verreck W, De Craene B, Poelmans P and De Volder M (2001) Rapport evaluatie startprojecten Open Universiteit Nederland, Heerlen
Wilson B, Teslow J and Osman-Jouchoux R (1995) The impact of constructivism (and Post-modernism) on ID fundamentals in Seels B B (ed) Instructional design fundamentals: A review and consideration Educational Technology Publications, Englewood Cliffs.
Wood D and Wood H (1996) Vygotsky, tutoring and learning Oxford Review of Education, 22 (1), 5-10.