Educational Modelling Language and Learning Design

Educational modelling language and learning design: new opportunities for instructional reusability and personalised learning

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Abstract: Learning technologies offer new opportunities to meet the rapidly growing demand for new, constructivist ways of learning (such as competency-based, collaborative or adaptive learning). They have the potential to act as catalysts for more effective exchange and reuse of learning objects to enable personalised learning. This article examines the extent to which current learning technology specifications contribute to educational change – to actual sharing and reuse in educational practice. Furthermore, the article describes the need for an Educational Modelling Language centred on learning activities to give instructional meaning to learning objects.

To date, specifications for learning objects have primarily been designed to ensure interoperability at a rather low infrastructural level (e.g., test items, meta-data), focusing on technology issues and reuse of learning objects. We argue that more widespread adoption of e-learning specifications and standards calls for a pedagogical framework at a higher infrastructural level (e.g., a complete course), focusing on the instructional value and reuse of learning activities. Such a framework is offered by the new Learning Design (LD) specification. LD enables the description of both learning content and processes from a variety of pedagogical perspectives, both objectivist and constructivist.

Keywords: learning activities; learning objects; personalisation; educational modelling language (EML); learning design (LD).

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Dr. J.M. Manderveld (1973) holds a degree in educational psychology (1997, University of Tilburg, Netherlands). She managed a number of educational projects for the Dutch Railways before joining the OUNL in 1998, where she has been involved in designing and developing flexible and rich learning environments, and in the development of EML. Jocelyn was OUNL project manager for the standardisation of EML and has participated in standardisation workgroups including IMS/LD and CEN/ISSS.

Dr. C. Tattersall (1965) gained a degree in computational science (1986, University of Leeds, United Kingdom) before conducting research into text generation for intelligent help systems at Leeds University's Computer Based Learning Unit, resulting in his PhD (1990). He worked in both the telecommunications and software industries before joining OUNL in late 2002, where his work includes harmonising IMS Learning Design with other IMS specifications.

Prof. Dr. E.J.R. Koper (1957) holds a degree in educational psychology (1986, University of Tilburg) and a PhD in educational technology. He worked as a teacher in higher education and was director of a teacher training company, joining OUNL in 1987. Rob became head of ICT application development and now holds a chair in Educational Technology (1998). He was the programme manager for R&D into Learning Technologies (1998-2002) that resulted in EML, IMS Learning Design, and tools for authoring and publishing, and currently leads the new program on Learning Networks (2003-2008). Rob chairs and advises several (inter)national ICT initiatives, and is an IMS Technical Board Member and is a Prometeus Steering Committee member.

1 Introduction

A growing body of professional educators feel the urge to improve the effectiveness of educational processes. Moreover, there is a pressing need for personalised and flexible learning without constraints of time and place. These demands are caused by societal trends such as life-long learning, the diminishing gap between working and learning, the increasing globalisation of education, and most of all by the possibilities of new technologies [1,2]. New technologies provide the means to integrate teaching and learning into every aspect of each person's life. There is a demand for new ways of learning, often based on constructivist principles [3-5]. Examples include *collaborative learning* [6,7] where discussion plays an important role in learning, *competence-based learning* [8,9] and *problem-based learning* [10,11], where knowledge is constructed by individual learners in solving real problems in realistic situations.

A major problem in realising new ways of learning is that educational changes tend to take place in isolation and are not always documented. Individual teachers and institutes choose their own issues and products, such as assessment forms, innovative textbooks, interactive media and Learning Management Systems (LMS). Teachers strive for maximum flexibility and freedom in customising their learning material (or learning *content*, as learning technologists prefer to call it) and learning processes. Teachers (and students) often have specific pedagogical demands which require customised approaches, as opposed to off-the-shelf solutions offered by external suppliers [12,13].

Customisation, then, seems a desirable element of innovation. However, the lack of transparency in professional practice and the lack of collaboration between teachers and between institutions hinder structural innovation. A good starting point would be to look for collaborative agreements between learning content specialists, for collaborative (specialised) development or reuse of learning content. More agreement on these issues would give the possibilities of reuse, interoperability and personalisation more depth and synergy.

Although technological standards impose demands on education, they can also be very supportive in realising new ways of learning. In terms of standardisation we can talk about general requirements and features of learning content and learning processes without having to restrict in any way specific pedagogical views (of individual teachers or institutes) on what learning should be about. Standardisation, then, does not restrict but facilitates customisation. Agreements on these requirements and features are recorded in specifications and taken up in the standardisation process. The field of learning technologies covers the development and recording of these specifications and standards.

Having introduced the potentially fertile relationship between new ways of learning and learning technologies, the central question to be answered in the remainder of this article is: To what extent do current learning technologies specifications already contribute to new ways of learning in educational practice, and what else is required?

In order to answer the question we first describe learning technologies specifications and the reasons for their development. We focus on (re-usable) learning objects, and possibilities for building learning objects to support personalised learning. We evaluate the extent to which current specifications support the building of personalised learning. Following on from this evaluation we argue the need for a pedagogical framework which relates learning objects to an instructional context (e.g. a complete course). Our conclusion contains conditions and expectations for the effective, worldwide uptake of such a pedagogical framework and for future implementations (for example in LMS).

2 Learning technology specifications

Learning technology (LT) is an area with many names but with few definitions [14]. Oliver and Bradley [15] define LT as the use of technology to support innovations of teaching and learning. We more narrowly define LT as '*specifications of methods and techniques which support the realisation of e-learning*'. Examples of specifications are:

- formats and rules for the design of a didactic approach
- competency profiles and assessment models (e.g., portfolios)
- personalisation models (e.g., flexible study arrangements)
- architectures and user interfaces.

The essential feature of specifications such as these is that they are independent of hardware and software.

The design and development of learning technology specifications is a global issue, and there are several initiatives underway:

- *Several industrial consortia are* developing learning technology specifications. IMS (Instructional Management Systems [16]) is probably the best known, a consortium of companies, universities and institutes. IMS is 'open', but membership requires a (substantial) annual subscription. Membership includes BlackBoard, WebCT, IBM, OUNL, and others.
- *Expert-based initiatives* include the IEEE LTSC (Learning Technology Standards Committee [17]) and ADL (Advanced Distributed Learning [18]). Another good example of initiatives based on the consensus of experts from universities and companies, is Prometeus (PROmoting Multimedia access to Education and Training in the EUropean Society [19] which is supported by the European Commission.
- Learning technology specifications are also developed at a *national or regional level.* In some countries (such as France or The Netherlands) standards are referred to as 'norms'. In the United States, ANSI [20] is producing learning technology specifications. At the European level CEN [21] does the same. Specifications from several countries and expert bodies can eventually become ISO (International Organisation for Standardisation) standards. It can take as long as five to ten years for specifications to gain worldwide acceptance, but once they become ISO standards they are ensured a long life. One of their Joint Technical Committees (JT1), subcommittee 36 (SC36), is currently responsible for standards on learning technology, but until now no official learning technology standard has been determined.

The form and structure of a specification varies considerably. Some specifications (such as those of IMS) use XML (eXtensible Markup Language), which is an 'open' modelling language and ensures independency of media and interoperability [22]. The essence of a specification however is provided by the information model that can be uniformly represented in UML schema. It is important that the specification is 'open', as this will enable other institutions to reuse and apply the material. Specifications that are developed within a 'closed' community tend be used only within that community or company. These developments tend to progress more rapidly, but at the same time they run the risk of addressing only one specific situation.

LT specifications have to be recorded in a clear, uniform, abstract and formal way. This is not only important for reuse and interoperability, but also for recognition by standardisation bodies. Standardisation leads to a more effective exchange and (re)use of learning objects [23], and we feel that widely adopted, open and accredited standards are a necessary requirement for revolutionary changes to occur in education. This has been demonstrated in other domains – in the case of electricity, it was the standardisation of voltage and plugs, for railroads, it was the standard gauge of the tracks and for the internet, it has been the common standards of TCP/IP, HTTP, and HTML [24].

We believe e-learning standards will offer a common language for sharing ideas without restricting customisation. Interested parties will be able to use the standards, exploiting their in-built flexibility to implement and adapt them to their own environment. Structural innovation in e-learning will be hampered until such standards are in place.

3 Reusable learning objects

To date, the focus of LT has been on developing specifications for learning objects. The learning objects movement has grown over the past few years, and is becoming increasingly mainstream. Several specifications and a standard for learning objects exist, and there is much interest in meta-data and packaging. Thinking in terms of learning objects has been triggered by the object-orientation approach in engineering, which values the creation of components (called 'objects') for subsequent reuse on a variety of platforms and in a variety of contexts [25].

3.1 Definition of learning objects

What is a learning object? Wiley [26, p.6] simply defines a learning object as '*any digital resource that can be reused to support learning'*. This definition is more specific than the strict LTSC [27] definition of a learning object that also includes non-digital resources such as persons, ideas, … at any time or place. Note that the IEEE/LTSC was founded in 1996 to develop LT standards, primarily to facilitate the widespread adoption of this (learning) object-orientation. We further refine the definition of a learning object as '*any digital, reproducible and addressable resource used to perform learning or support activities, made available for others to use*.'

This definition excludes many things, e.g. non-digital materials, non-reproducible unique exemplars, non-addressable resources (i.e. when not connected with a URL and metadata for access). It also excludes courses (being a composite of learning objects and learning activities) and 'persons', 'activities' and 'services'. Reuse is the central element of learning objects, as generativity, adaptivity (e.g., personalisation), learning activity and other activities are all facilitated by the properties of reuse [26]. However, reuse is also a weakly defined concept, but can be narrowed down by following our definition of a learning object.

3.2 Instructional design literature and learning objects

The majority of literature trying to explore the instructional value of learning objects was written by M. David Merrill and his team at Utah University [28]. Merrill departs from Instructional Transaction Theory (ITT), and distinguishes four types of learning objects: entities (objects in the world like devices, persons, places); properties (attributes of entities); activities (actions the learner takes on objects in the world); and processes (events that change properties, triggered by activities). Merrill's more recent studies on learning objects leans heavily on Gagné's Conditions of Learning. The assumption of all instructional design theories and models such as ITT, Conditions of Learning, and others such as the Four Components / Instructional Design (4C/ID) Model of Van Merriënboer [29] is to some degree an objectivist one, and can be associated with the metaphor of the "Mind as a Computer". According to this view, when executing (complex) tasks the human mind manipulates information in the same algorithmic way a computer manipulates digital data. Both learning content, and (the sequence and combination of) learning processes can be designed in advance for all students, and solutions or answers are either right or wrong, as in, for example, a multiple-choice question.

In sharp contrast to these cognitive information processing approaches are alternative perspectives which stress the flexible dissemination and use of content, such as Cognitive Flexibility Theory [30], and the personalisation and contextualisation of learning processes, such as Situated Cognition [5]. These approaches advocate that instructional design cannot be algorithmic and should take into account multiple perspectives on content and not rely on a single schema [31]. Moreover, knowledge is continuously under construction and evolving for every student, activity and situation. Rather than acquiring knowledge as self-contained, abstract entities, the emphasis is on acquiring useful knowledge through enculturation (understanding how knowledge is used by practitioners).

3.3 Learning objects versus learning activities

Interoperability has been the dominating element in specifying learning objects, mainly because vested interests in commercial applications are huge. *Learning objects* are likely to become *the* instructional technology and the world will be flooded with learning object-based tools. Vendors therefore have stressed the importance of recognition, adoption, and the potential for future support.

However, technical standards and venture capital are important but not enough to promote learning. In order to promote learning, technology-enabled learning should also be guided by instructional principles. Without attention to the process of instruction, interoperability and reusability of learning objects will not materialise. Educational designers must first establish how individual students could be studying most effectively. There is a growing feeling of uneasiness, a feeling that the primacy of reusable learning objects is leading to e-learning as page-turning, that the people-to-content model leads to "static, fossilized, dead [content], low learner motivation [and] engagement, impersonal [and] isolating environments" [32]. Software vendors and standards bodies offer products that are presented as 'instructional theory neutral' (e.g. in the information model of the IMS Content Packaging specification). However, we feel most of the commercially available LMS nowadays reflect old ways of learning embedded in objectivist views on learning. In the worst case their possibilities are limited to 'clip-art slide shows' on the web, not allowing for any active role of the learner.

The recently approved Learning Design (LD) Final Specification [33] provides a counter to the trend towards designing for lone learners reading from screens. It guides staff and educational developers to start not with content, but with *learning activities* and the achievement of learning objectives. It recognises that learning can happen without learning objects, that learning is different from content consumption, is highly personal and that learning comes from being active. It recognises, too, that learning happens when learners cooperate to solve problems in social and work situations. In all this, it stresses that we must focus on the learning in e-learning, and it is this focus which makes it important for staff and educational developers. Before describing the Educational Modelling Language, developed by the Open University of the Netherlands and the basis for LD, we will first turn to the issue of adoptability and personalisation.

4 Personalising learning

Building individualised learning activities to support personalised instruction in an adaptive environment is a big challenge for the future of e-learning. The web offer the perfect technology and environment for individualised learning, since learners can be uniquely identified, content can be specifically personalised, and learner progress can be monitored, supported and assessed. The greatest benefit of learning personalisation is the system's ability to make complex instruction and learning easier. According to Martinez [34, p.156] this is achieved by

> "… presenting only the specific information that a particular learner wants or needs in the appropriate manner and at the appropriate time. Each time you personalise, you learn and store a little more about a learner's unique set of needs."

In order to further clarify the concept of personalisation, Martinez [34] distinguishes five levels of increasing sophistication:

1 name recognition

2 self-described personalisation (study preferences based on e.g. a pre-quiz)

3 segmented personalisation (different sets of content for learning groups)

4 cognitive-based personalisation (e.g. text/audio or linear/hypertext presentation of content)

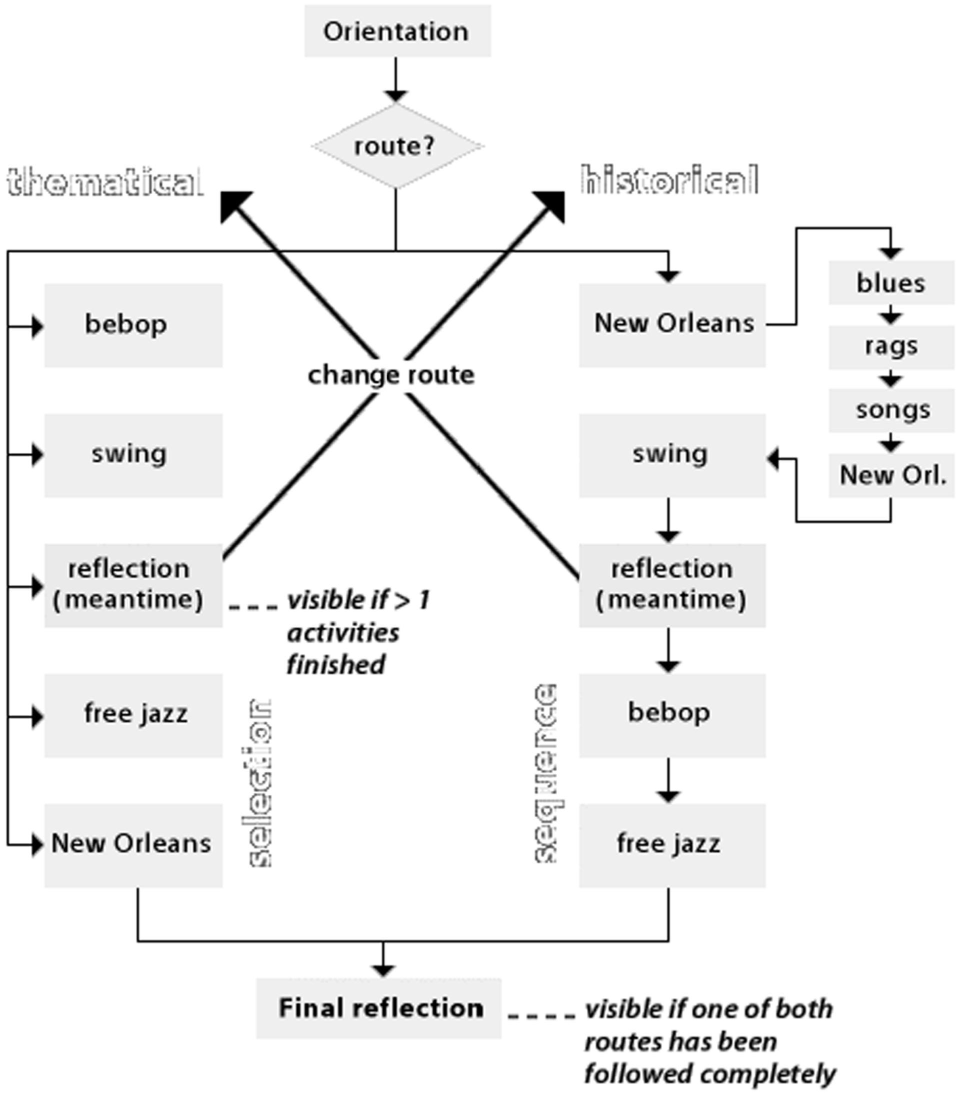
5 whole-person personalisation (making predictions about the delivery of the content).

Modelling the educational process will bring new opportunities and benefits for personalised learning. Current developments with Life Long Learning are leading to an increase in heterogeneity within the total population of learners, who demand more adaptive and customised learning environments. Example 1 describes a course (the unit of study) on 'Learning to listen to jazz' that was created using Educational Modelling Language (EML). It demonstrates personalising at level (3) for both the learning content and the learning processes. Personalisation will have even more potential at the curriculum level (a collection of units of study), where both teachers and students are able to define their own study arrangements according to their own prior knowledge, preferences or intentions.

4.1 Example 1: personalisation in the jazz course

The course "Learning to listen to jazz" was designed and modelled in EML as a self-study course that can be taken individually. The objective is to learn how to distinguish between rhythm and melody when listening to jazz, and is constructed so as to give students individualised learning pathways. Based on an intake assessment, the student will be given advice about the learning pathway, depending on their previous knowledge and learning style (previous knowledge test and study approach test). The teaching method chosen is based on self-assessment. This means that students judge for themselves their grasp of the subject matter and choose whether or not to follow the advice on which learning pathway to follow. This design means that students not only learn about listening to jazz, they also get an insight into the way they learn and whether a particular type of course material suits the needs of the student. The scenario of the whole course is summarised in Figure 1.

Figure 1 Didactical scenario of the jazz course



After choosing the most suitable route in the 'orientation' on the basis of the test results, either the historical or the thematic route can be followed. Halfway through the course, students are once again offered the option to change the route for the rest of the course. Using the thematic route, they can jump from style to style. In the historical route, the sequence presented is recommended to be followed. After finishing a whole route, a final reflection is made available to the student. The whole course was tagged in EML, using

Framemaker+SGML in combination with the EML DTD. To give you an idea of the size of the source XML file, the printed document runs to 122 pages.

4.2 Further requirements

We now return to the central question raised in this article: To what extent do current LT specifications already contribute to new ways of learning in educational practice, and what will be required further? Most design efforts for learning objects and learning technology specifications have avoided critical instructional design issues. As a result the need for a pedagogical framework to achieve instructional objectives has been ignored. In addition to the need for personalised learning content (illustrated in Example 1), there is also a need to define how various learning processes relate to one another, and how these can be used together according to particular didactic approaches for complete learning tasks.

The current specifications for learning objects address various components of a learning task, but none is fit to model 'whole-tasks' (or units of learning). Relatively few learning objects can be described, being mainly restricted to samples of learning material and test items. Due to their origins, most object-oriented learning systems and learning technology specifications have focused on interoperability issues, such as attributes, data interchange protocol, tool agent communication, meta data standards and the technical architecture of the system [35] and to a lesser extent on reusability issues. As a result of this focus on technical and technological issues, giving the various learning objects instructional meaning has been neglected. For the future development of *educational* technology and technology-enabled *learning*, it is now crucial to first give some thought to using learning objects for new ways of learning before implementing this technology on a large scale (e.g., in LMSs). As long as learning objects lack instructional meaning, we will not be able to use them effectively, which will hinder the structural innovation of education. Educational Modelling Language and Learning Design provide an instructional framework to model both learning content and processes (e.g., to personalise learning objects), and also describe the didactic / instructional relations between various learning objects. This framework was researched, designed, developed and implemented by the Open University of the Netherlands.

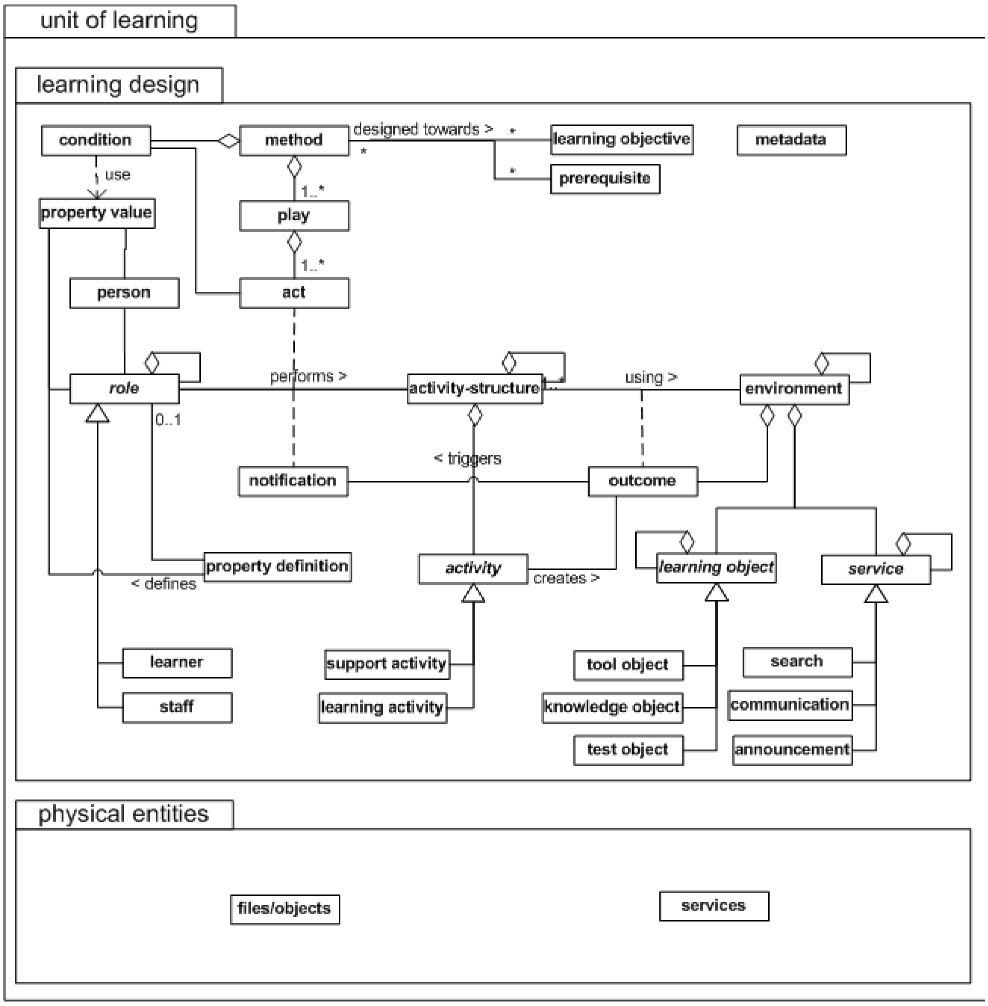
5 Educational Modelling Language and Learning Design

Educational Modelling Language (EML) is a notational system developed by the Open University of the Netherlands (OUNL) in the late 1990s and intended to describe a wide variety of instructional models (for example, Competency Based Learning, Problem Based Learning). At the heart of the specification is a model which underlies many different behaviourist, cognitive, and (social) constructivist approaches to learning and instruction. The model revolves around describing 'units of learning', atomic or elemental units providing learning events for learners, satisfying one or more interrelated learning objective.

Once described in EML, these models are able to be interpreted (or 'played') by an EML-aware software component (or 'player'), analogous to the way HTML is interpreted by a browser. A prototype EML player has been used at OUNL and partners throughout the world for the past couple of years and a production-quality player is currently undergoing final field trials. So far, thousands of study hours of learning material in a variety of instructional models has been created and is still 'up-and-running'.

EML has about 400 different elements and is implemented in XML. The highest level, a *unit-of-learning*, could be a whole course, a module within a course, and so on. There is no predetermined notion of how large a unit-of-learning should be. This is a powerful concept, since every unit-of-learning can consist of smaller units-of-learning, enabling complex structures. Such a unit-of-learning is defined as 'a systematic aggregation of learning activities that are necessary to reach certain learning objectives, including the environments and resources that are needed for executing those activities.' The environmental resources can be used in several learning activities and units-of-learning [36]. The EML unit of learning model is presented in Figure 2.

Figure 2 Semantic information model of a unit of learning expressed in UML



In its approach to modelling both learning content and learning processes, EML innovates in the world of learning technologies. It can be used to create adaptable and flexible personalised learning experiences, and is able to support all five levels of personalisation as described by Martinez [34] and a wide variety of didactic approaches. EML contains a pedagogical metamodel [36] making it possible to design education from a variety of different pedagogical approaches: from more constructivist approaches to more objectivist views on learning.

EML was selected as the basis for IMS Learning Design 1.0, which was approved as an official IMS Final Specification on 10 February 2003. As a result, EML is no longer maintained or updated and OUNL's attention is now focused on IMS LD (a description of the differences between EML and LD goes beyond the scope of this article). EML and LD share the same philosophy and aim: *In a unit of learning, people act in different roles in the teaching-learning process, working toward certain outcomes by performing learning and/or support activities within an environment, consisting of learning objects and services to be used during the performance of the activities*. The approach separates *learning objects and services* (modelled outside LD) from the educational *method and learning activities* used in the unit of learning (modelled inside LD). These physical entities represent the actual content used within a unit of learning. These can be files or objects (tool, knowledge and test objects). Figure 1 describes the unit of learning model. The unit of learning consists of two packages: learning design and physical entities. Learning design basically describes the relationship between roles, activity-structures and environments. The core concept is that learners perform learning activities in an environment. This is elaborated in various ways:

- learner and staff are organised in roles which can be nested
- activities are organised in activity-structures which can be nested
- environments consist of learning objects and services
- performing an activity creates an outcome, which can be stored in the environment. The outcome of an activity triggers a notification, which has consequences for the pedagogical design of a unit of learning
- a unit of learning is designed towards certain learning objectives and prerequisites. The flow of activities which happens during the learning process is modelled as a theatrical play consisting of a series of acts
- the flow of activities represented can be influenced by notifications and conditions.

Two examples of the use EML/LD in relation to personalisation are presented in this article. Example 2 gives *an impression* of the LD specification on the level of complete units-of-learning or 'whole tasks' (e.g., a course on LT), and its possibilities for personalised learning processes.

5.1 Example 2: complete 'unit of learning' modelled in IMS LD

A complete, though very simple course on LT, modelled in IMS LD, is now given to emphasise the structure and relations between components and to illustrate the potential to personalise learning processes. To achieve the learning objective, this course consists of three learning activities. The student can choose between studying with or without examples. So every student gets different sets of content. Components in the (learning) 'environment' are required for execution of the second activity. This article is the only 'knowledge object' that can be studied within this environment.

Figure 3 Example 2: complete 'unit of learning' on learning technologies

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               </imsld: roles>
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                     </imsld: locpers-property>
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</imsld:learning-design>
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students can decide if they want to study with or without examples. The examples are bracketed by a DIV-element
in XHTML and the DIV-element has the class-attribute “C-examples”. In the play’s conditions the class attribute is
set to either hide or show the examples.- – >
   </resource>
   <resource identifier="R-Preparation" type= "imsldcontent"/>
        < ! – - the resource R-article contains the description of the activity “Preparation”. – - >
   </resource>
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   < ! – - the resource R-article contains the description of the activity “Assignment 1”. – - >
</resource>
        <resource identifier="R-Assignment-2" type= "imsldcontent"/>
        < ! – - the resource R-article contains the description of the activity “Assignment 2”. – - >
        </resource>
   </resources>
</manifest>
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6 Conclusion: conditions and expectations

Learning technology specifications have been primarily developed to ensure the interoperability of learning objects at rather low levels of granularity (like test items), focusing on the technological value and use of learning objects. What is also needed to contribute to new ways of learning in educational practice is a pedagogical framework that structures the relations between various learning objects, and redirects attention to the instructional value and use of learning objects. The real challenge is to reach agreement on what constitutes a meaningful combination of learning objects in real learning activities, to be aggregated at higher levels of granularity (like complete courses). Such a pedagogical framework preferably is general enough to support both old (objectivist) and new (constructivist) ways of learning to ensure that specifications will be widely (re)used. LT specifications that have been developed so far are not fit for being used by teachers and designers to innovate education, often because the LMS they are implemented in still reflect an objectivist view on learning that does not allow for new ways of learning.

EML and LD are LT specifications that describe both learning content and processes within ‘units of learning’, or whole tasks (like a course). They contain a pedagogical meta-model (or framework) that supports a large variety of didactical approaches (both objectivist and constructivist). We included two examples of personalisation in courses modelled in EML and LD in this article, and argued why such a pedagogical framework could support new ways of learning.

Since IMS LD separates learning approaches and activities from the learning objects and services used, new opportunities for reuse are raised:

- Individual learning designs can be applied across different domains. Each time, different content is coupled to the same activities of the learning design.
- Learning objects can be used in different educational models. Each time, different activities are associated with the same content.

EML has already been implemented within and outside the Open University of the Netherlands and is ‘up and running’ in a large variety of higher education courses and training programs. A commercial version of the Edubox™ player is under construction.

We are currently faced with two major concerns or conditions for further uptake. Since it is only a matter of weeks since the IMS LD specification was approved, no IMS LD player yet exists. As a result, an important part of the benefit of IMS LD cannot yet be reaped – it is not yet possible to author an XML file coupling activities to resources and services as described by the specification and have this interpreted in an IMS LD-aware software environment for learners. However, we are confident that this situation will soon change as Learning Management System vendors familiarise themselves with the opportunities afforded by the specification. We are also exploring ways in which the available EML players might be ‘upgraded’ to become IMS LD aware.

Another major concern in the implementation will be the teachers’ perspective and the uptake of LD in educational practice. Teachers will only use LD if it allows them to teach in the way they want, and be rewarded for applying it. Moreover, use requires good tools, such a user-friendly yet flexible authoring environment, and a powerful and reliable player. As a result of these needs, a large group of institutes and companies have started to work together as the so called ‘Valkenburg group’ to develop a user-friendly authoring system. This system will help to realise EML and LD’s potential while maintaining possibilities for teachers to use different pedagogical models when designing their units of learning.

Nonetheless we feel staff and educational developers can already benefit from the philosophy of IMS LD by focusing on learners' activities and objectives, and designing e-learning environments with this philosophy in mind. The vision towards which we are working sees educational best practices available as reusable learning designs, able to be downloaded and customised by staff and educational developers, coupled to (reusable) learning objects and interpreted by IMS LD aware environments, giving learners the stimulating, active, challenging and exciting experiences they deserve.

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