

Usability of a Runtime Environment for the Use of IMS Learning Design in Mixed Mode Higher Education

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ABSTRACT

Starting from the first public draft of IMS Learning Design in November 2002, a research project at the Catholic University Eichstätt-Ingolstadt in Germany was dedicated to the conceptual examination and empirical review of IMS Learning Design Level A. A prototypical runtime environment called 'lab005' was developed. It was built based on Moodle, a web-based, open source course management system. Development and use of the lab005 runtime environment were intensely evaluated. Several university courses provided a use case for the empirical review of IMS Learning Design, which covered mainly two issues: firstly, whether IMS Learning Design can be used to support mixed mode learning scenarios (use for blended learning), and secondly, how users interact in learning situations with a learning environment for IMS Learning Design (usability in terms of human-computer interaction). This article gives an overview of the web-based learning environment lab005, its underlying concepts and outcomes of experimental use and evaluation. Though limited in scope, the successful implementation of IMS Learning Design in higher education proves the possibility to support mixed mode learning scenarios. Key concepts for the graphical user interface of lab005 are illustrated in order to give insights into the use of IMS Learning Design in mixed mode learning scenarios. Details in the results of evaluation concern the classification of learning objects, the use of environment as an element in IMS Learning Design and challenges in the application with face-to-face situations and with real life objects in classroom learning scenarios.

Keywords

Blended Learning, Learning Environment, IMS Learning Design in Practice, Runtime Environment for IMS Learning Design, Moodle

Introduction

When IMS Learning Design was released as a final specification in February 2003, neither runtime environments nor authoring systems were existent. Some exemplary learning scenarios, which could serve as proof of concept, were described in the IMS Learning Design Best Practice and Implementation Guide (Koper et al., 2003a). But successful and practical application of the core concepts in single learning scenarios or on a large scale was a task still to be fulfilled. Today, initial information systems, appropriate reference architectures as well as some examples of implementation in practice are at hand (Koper & Tattersall, 2005).

Yet, in the very beginning, IMS Learning Design was a future concept to be conceptually examined and empirically tested. The core concepts of IMS Learning Design had been taken from the Educational Modelling Language (EML) of the Open University of the Netherlands (Koper, 2001). Within the discussion on reuse and standardisation, they offered a remarkable shift from content to process and thus to learner-centred approaches like situated learning and social-constructivist learning – towards computer supported cooperative learning (CSCL) scenarios as well as towards the integration of web-based self-study with traditional classroom teaching (blended learning), and away from the paradigm of content-based knowledge delivery. However, the application of these concepts in practice still had to be proved.

Background

Starting from the first public draft in November 2002, a research project at the Catholic University Eichstätt-Ingolstadt in Germany was dedicated to the conceptual examination and empirical review of IMS Learning Design Level A. The objective of this research project was to evaluate the scope of IMS Learning Design from a theoretical perspective based on specific German approaches towards teaching and learning. Several courses at the Catholic University Eichstätt-Ingolstadt provided a use case for this evaluation. There was no intention to fully implement IMS Learning Design at university; practical use merely aimed to test it within these mixed mode courses. Two main issues were covered by this empirical review: Firstly, can IMS Learning Design be

used to support mixed mode learning scenarios (blended learning)? Secondly, how do users in learning situations interact with a learning environment for IMS Learning Design in terms of usability for human-computer interaction?

As neither runtime environments nor authoring systems existed, at least a runtime environment for the use of IMS Learning Design in teaching-learning scenarios was needed. In order to facilitate the creation and running of mixed mode units of learning in higher education, a prototypical runtime environment called 'lab005' was developed. As a graphical user interface to be used in classroom teaching as well as for self-study, this web-based learning environment was built extending Moodle, an open source course management system (<http://www.moodle.org> and Dougiamas & Taylor, 2002). While the web-based learning environment lab005 was developed, units of learning had to be designed conformant to IMS Learning Design. By now, seven university courses (and an exemplary unit of learning for use in usability tests) have been developed and are operated on a regular basis.

The specification IMS Learning Design starts from the concept of 'units of learning'. A unit of learning is to be considered as a single unit that is designed towards one or more learning objectives. Hence, a unit of learning is a self-contained period in a teaching-learning process, limited in time and dedicated to a certain issue of a subject that is studied (Koper, 2001). For practical use, we decided that a university course spanning a whole term covers a number of units of learning (i.e. plays in IMS Learning Design). Their sequence resembles chapters in the course. Within the weekly organisation of university courses, each may span one or several weeks, depending on learning objectives, subject matter and arrangement of the teaching-learning process.

Development and use of the runtime environment lab005 was intensely evaluated from the perspective of users in mixed mode learning scenarios, both staff and learners. The evaluation did not intend to prove advantages and disadvantages of one or another pedagogical approach. A main objective of the IMS Learning Design specification is to be pedagogically flexible (Koper et al., 2003b), hence to be both rich and neutral in an educational sense. Pedagogical information should be enclosed and expressed in units of learning, but instructional designers must not be restricted to specific pedagogical models. For that reason, no specific pedagogical approaches were taken for the conceptual examination and empirical review of IMS Learning Design in the observed university courses. On the contrary, the regular educational settings of these courses were taken as a proof for the scope of IMS Learning Design. The courses were weekly seminars that combined lecture, discussion, group work and hands-on experience with self-study for preparation and research. According to topics of the courses case studies, problem-oriented learning and learning assignments were used to structure the teaching-learning process. In doing so, the emphasis on process instead of content and on learning activities as a core concept led to a certain shift in the design of the courses.

Intentions and Scope

Rather than proving advantages or disadvantages of individual pedagogical approaches, development and experimental use of the web-based learning environment lab005 was dedicated to the evaluation of core concepts of IMS Learning Design. The main focus was given to the practical use of IMS Learning Design in teaching-learning scenarios, and thus to the realisation and application of units of learning conformant to IMS Learning Design in the context of normal courses at university. The following interpretation of the core concepts served as hypotheses for the evaluation:

- Learning activities and supporting activities are adequate concepts to describe a teaching-learning process.
- In order to describe a teaching-learning process, learning activities and supporting activities can be organised in a hierarchical and sequential structure.
- A plan for a process of teaching and learning can be organised separately from resources for teaching and learning.
- A classification of resources for teaching and learning enhances a learner's comprehension of the teaching-learning process.
- Through the description of the teaching-learning process, traditional classroom teaching can be integrated with web-based self-study, in order to support mixed mode learning scenarios.

These aspects reflect two questions covered by the empirical review: Can IMS Learning Design be used to support mixed mode learning scenarios? How do users in learning situations interact with a learning environment for IMS Learning Design in terms of usability?

Resources for implementation were limited, so lab005 was developed as a prototypical runtime environment. It was built towards the requirements of use in the observed university courses and the purposes of evaluation. Hence, only a subset of Level A from the specification IMS Learning Design was implemented. This subset focussed on learning activities and supporting activities, their organisation in hierarchical-sequential structures and the delivery of resources for learning, such as learning objects and services. Other concepts, like the concept of 'on completion' in Level A (Koper et al., 2003b), were not implemented. This limited scope provided the possibility to react rapidly to user requirements, which were formatively evaluated as feedback for improvement of the web-based learning environment.

There were no authoring features implemented. Units of learning were created using standard applications, especially for editing and validating the XML-files needed for IMS Learning Design. Using an advanced XML-editor proved to be quite efficient though editing learning designs in pure XML is a task that requires profound understanding of both XML and the specification.

Even if limited in scope, the successful implementation of IMS Learning Design in higher education proves the core concepts of IMS Learning Design, especially the possibility to support mixed mode learning scenarios (Klebl, 2005).

Building a Prototypical Runtime Environment: lab005

Various functions, which are essential for web-based learning environments, are independent from IMS Learning Design: features like management and delivery of resources for learning, management of courses and users including authentication and access and, finally, web-based communication services are provided by various learning management systems. Therefore, the idea to extend an existing learning management system for an experimental use of IMS Learning Design suggested itself. Obviously, an open source system offered best opportunities for extension. Moodle, a web-based, open source course management system was chosen as a learning management system that provided ample functions for management of resources for learning, users and courses. lab005 was built based on Moodle as an extension in order to enable Moodle to act as a prototypical runtime environment for IMS Learning Design Level A. So lab005 basically adds two features to Moodle: firstly, course structures conformant to IMS Learning Design Level A and secondly, a presentation level for compatible units of learning. As stated above, this extension to Moodle was limited in scope and implemented only a subset of Level A.

The following part of the article describes the prototypical runtime environment lab005, which is used to run mixed mode courses at university. Relevant modifications to the Moodle open source course management system and the approach for usability evaluation are described in brief. An account of viable concepts for the graphical user interface completes this section.

Starting from Moodle

Due to limited resources for development and operation, the choice for the development of lab005 was limited to web-based systems based on PHP and MySQL. A brief evaluation of open source learning management systems available in February 2003 resulted in a decision for Moodle (at that time version 1.0.8.1).

In Moodle, learning objects and services are implemented as 'modules' (such as resource, assignment, chat, forum, journal or quiz). Instances of modules, i.e. learning objects and services used in a course, are inserted within sections that form the course structure. Hence, resources for learning can be arranged to organise the teaching-learning process according to predefined course formats. Course formats are templates for course structures. Default course formats in Moodle are 'topic format', 'weekly format' and 'social format'. Thus instances of modules, i.e. learning objects and services, can be arranged in relation to topics according to weekly sessions or around discussion forums.

Functions for course formats are implemented separately from functions for modules. This offers the possibility to create new course formats for Moodle. Thus, a new course format called 'imsld' was implemented for lab005. This new course format provides functions to use Moodle as a runtime environment for units of learning compliant to IMS Learning Design Level A.

In this course format, resources for learning can be arranged according to the above named core concepts of IMS Learning Design. The required course structure for lab005 is described in the file `imsmanifest.xml`, which is conformant to XML-schemas for IMS Content Packaging and IMS Learning Design Level A. Resources are referenced from this file using the identifier for instances of modules in Moodle, which is a consecutive number for all instances of learning objects and services.

According to the IMS Learning Design Level A specification, the course structure is built from plays, acts, activity structures and activities, where the latter two are assigned to roles through role-parts. All resources for learning (i.e. instances of modules in Moodle) are inserted within environments (in terms of IMS Learning Design), which are connected to activities. In this way, it is possible to edit the file `imsmanifest.xml` in an XML-editor and thus create the learning design with learning and supporting activities, which are organised in plays, acts, and activity structures respectively and with associated environments.

The graphical user interface of the web-based learning environment lab005 offers different views of the course structure (see details below), depending on role, progress in the teaching-learning process and user's choice. For these views, the information in the file `imsmanifest.xml` for a running unit of learning is processed (on the server side through XSL transformations and access to the XML-DOM) and presented to both learners and teaching staff in the web-based learning environment lab005. In order to integrate different views on the course structure conformant to IMS Learning Design well into the whole graphical user interface, a unique presentation level was also developed. For that, Moodle offers the possibility to integrate custom themes. Figure 1 shows the resulting architecture for the extension of Moodle to lab005, with extended components marked in grey.

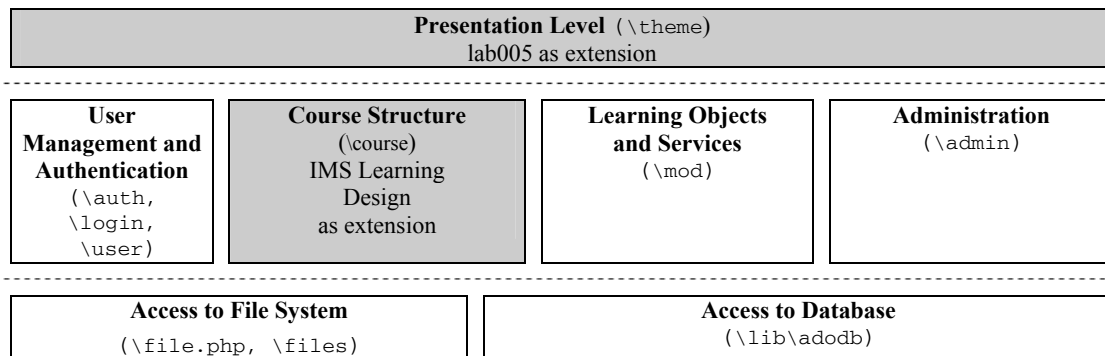


Figure 1. Modification of Moodle for prototypical runtime environment of IMS Learning Design

A Formative Approach to Usability Evaluation

IMS Learning Design is designed as a framework for a comprehensive description of the teaching-learning process consisting mainly of an information model and the binding to XML. Instructional designers may use it as a notation system for creating learning scenarios in pure XML or with specific editors. Nevertheless, while operating units of learning conformant to IMS Learning Design, learners and teaching staff will never encounter any XML; they will use a graphical user interface and normally interact with a web-based learning environment based on IMS Learning Design. So in practical use, issues of suitability, completeness and scope of a specification like IMS Learning Design can be examined only through the usability of the user interface for an information system. Usability of a runtime environment for IMS Learning Design applied to units of learning can reveal aspects of suitability, completeness and scope of this specification. As stated in ISO 9241-11, usability relates to effectiveness, efficiency and satisfaction in the use of a product regarding a specified context, specified users and a specified goal (Çakir, 2000). Hence, in the context of courses at university, students (and teaching staff) use a web-based learning environment for IMS Learning Design in order to study and learn.

The representation of the course structure was designed to reveal underlying concepts of IMS Learning Design in a meaningful manner for both learners and teaching staff. Through formative evaluation, user requirements were observed and analysed. A formative approach was chosen for usability evaluation, in order to understand strengths and challenges of both IMS Learning Design and its tentative implementation in lab005. Thus, the formative evaluation provided rapid feedback for improvement of the web-based learning environment. During an iterative process (development on the one side and use in practice on the other side) four different versions of lab005 were reviewed in usability tests with students and usability workshops with experts.

In usability testing, qualitative and quantitative methods were combined. In a quantitative approach, each of the four versions of the graphical user interface were evaluated in a usability test. In these usability tests, which lasted two hours, students first completed an exemplary unit of learning and then rated aspects of usability with a questionnaire. This questionnaire was adopted from the IsoMetrics usability inventory (Hamborg, 2002) and adequately modified. For the qualitative approach, experts were invited for usability workshops lasting half a day. They were asked to examine and discuss use and usability of the web-based learning environment based on heuristic criteria, which were taken from Rolf Molich and Jakob Nielsen (developed in 1990, retrieved in a German translation, Schweibenz & Thissen, 2003). The usability workshops were scheduled during the development of an enhanced version following a qualitative usability test with students of the former version. So both results from the test of the former version and the outline for the next, enhanced version were able to be discussed. A comprehensive account of the evaluation can be found in Klebl (2005).

A major improvement in usability was noted for evolving key concepts of the graphical user interface from the second to the third of all four reviewed versions of lab005. This improvement was especially evident for two dimensions of usability:

- Firstly, the dimension ‘user control’ improved significantly comparing the latter two versions to the second version. Usability aspects belonging to ‘user control’ include simple navigation and ease of access to functions and resources.
- Secondly, the dimension ‘immediate orientation’, which gathers aspects of usability concerning the comprehension of the outline for a unit of learning, showed improvement of the latter two versions compared to the second version, significantly for the fourth compared to the second.

Hence, some features and characteristics in the graphical user interface of the latter two versions of lab005 are considered as appropriate concepts for implementing IMS Learning Design in a runtime environment. As viable key concepts, the main characteristics of the latter two versions are described in the next section. In the subsequent section, some relevant conclusions will be drawn from these concepts regarding the use of IMS Learning Design, especially in connection with mixed mode learning scenarios.

Viable Concepts for the Graphical User Interface

In this section, key concepts for presenting units of learning in the graphical user interface of lab005 are illustrated in order to give insights to the use of IMS Learning Design in mixed mode learning scenarios. These concepts concern the representation of core concepts in IMS Learning Design, including the representation of a hierarchical and sequential organisation of learning (and supporting) activities. Subsequently, the representation of both single activities and resources for learning is discussed. Finally, the question as to how progress in the teaching-learning process can be marked is examined.

Taxonomy and Sequencing in the Activity Tree

As in most runtime environments already implementing IMS Learning Design (e.g. the LD-player provided by CopperCore, Martens & Vogten, 2005), a tree view is used in lab005 to illustrate the plan for the teaching-learning process (see Figure 2). The aggregation of single activities within container elements such as activity structures, phases (in LD terms ‘acts’) and methods (in LD terms ‘plays’) to a teaching-learning process is represented by an activity tree, which is a central instrument for navigating a unit of learning.

A tree-based organisation of informational elements is very common to graphical user interfaces ranging from file systems to web-based information systems. A tree for the organisation of informational elements is comfortable and well known, but lacks a sense of process structure with subsequent, parallel and unordered elements. Especially activity structures, which allow both sequencing and choice for subordinate activities, must to be marked to indicate the flow of the teaching-learning process. Therefore, in lab005, sequenced activities (resp. sequenced subordinate activity structures) are linked with arrows [A], while activities for choice (or subordinate activity structures for choice) are identified by radio buttons, as indicated in the following screenshot.

The first versions of the graphical user interface of lab005 offered the entire activity tree for a course to the user: from root, i.e. the learning design itself, through acts, activity structures, activities and environments down to learning objects and services. As usability studies showed, an entire tree for a course is far too complex for comfortable navigation. In the latter versions, the activity tree was divided into three levels of details in aggregation, each of them serving a special purpose: Firstly, there is a view of the whole course, secondly a view

of a unit of learning in the course (Figure 2), and thirdly a special view of a single learning (or supporting) activity (Figure 3).

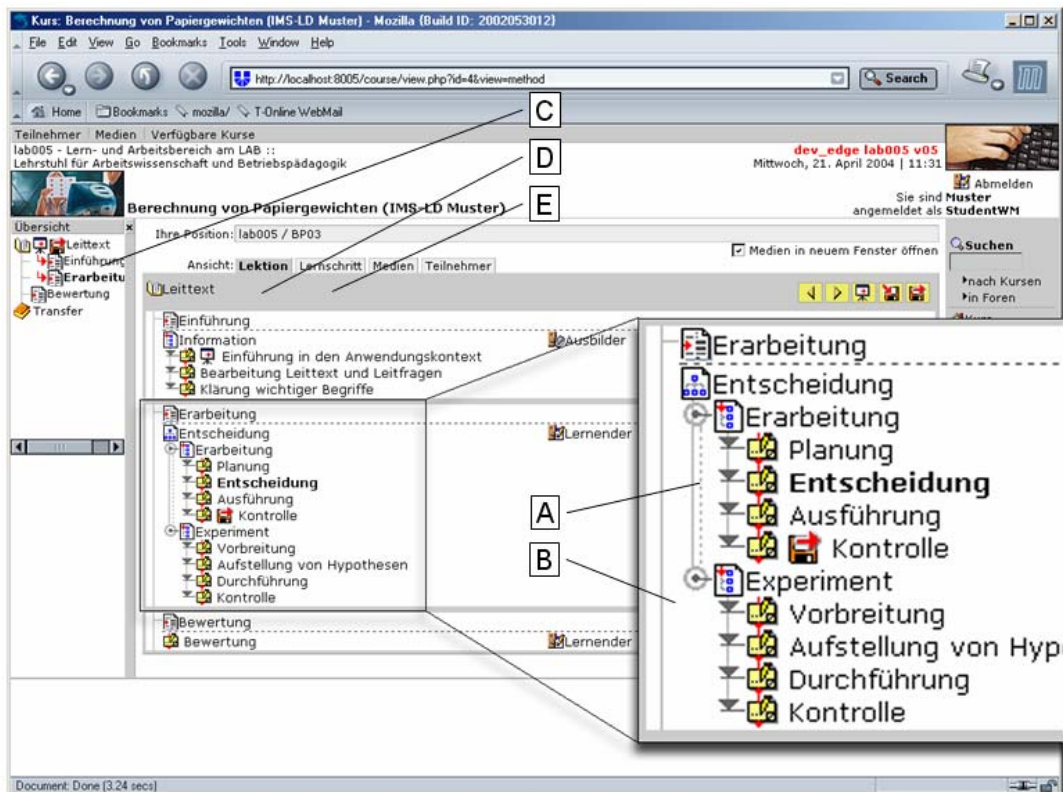


Figure 2. Screenshot of Activity Tree in lab005

- For an initial view of the whole course, a tree with two levels represents a number of units of learning [C]. Several units of learning (i.e. plays) are sequenced like chapters in a course spanning a whole term. A unit of learning may span one or several weeks within the weekly organisation of university courses. For practical reasons, the multiplicity of plays subordinate to a method element within a learning design was treated as a sequence of plays. In addition to this first level, symbolised by books, a second level shows phases within these chapters (i.e. 'acts' in LD terms). This outline for the whole course is found on the starting page for a course. Further on, this overview can be accessed at any page in a sidebar for quick navigation through the course.
- In addition to this overview for the whole course, an activity tree unfolds for a chapter when a user chooses a chapter or a tab in order to view the current chapter [D]. This activity tree displays phases (i.e. 'acts' in LD terms), activity structures and activities. In the latter versions of lab005 this view for a teaching-learning process was put on a card with a tab and did not include elements of the learning environment nor features for collapsing or expanding elements. Hence, structure and steps in the planned teaching-learning process are represented in a simple, comprehensive way.
- Thirdly, single activities can be chosen and a second tab [E] next to the tab for this view of a chapter allows a view of the current activity (Figure 3). In this way, individual learning (or supporting) activities are represented on a screen that becomes a cue-card for performing these activities.

These three levels of aggregation for the teaching-learning process provide the opportunity for a fast and comfortable information zoom. They lead a learner from the overview of the whole course down to a single activity that stands for a task that has to be fulfilled at a given moment in the teaching-learning process. As levels, they correspond with the given taxonomy of plays, acts (with role-parts), activity-structures and activities in IMS Learning Design.

Cue-Cards for Activities

In the latter versions of lab005, a special metaphor for both learning and supporting activities was introduced: The view for a single activity becomes a cue-card (Figure 3). The activity description is central to this screen

[A]. It is completed by a title [B], the title for the play to which this activity belongs [C] and by the role to which this activity is assigned [D]. This cue-card can be accessed through a second tab next to the chapter view tab. Whenever an activity is chosen, this cue-card is presented.

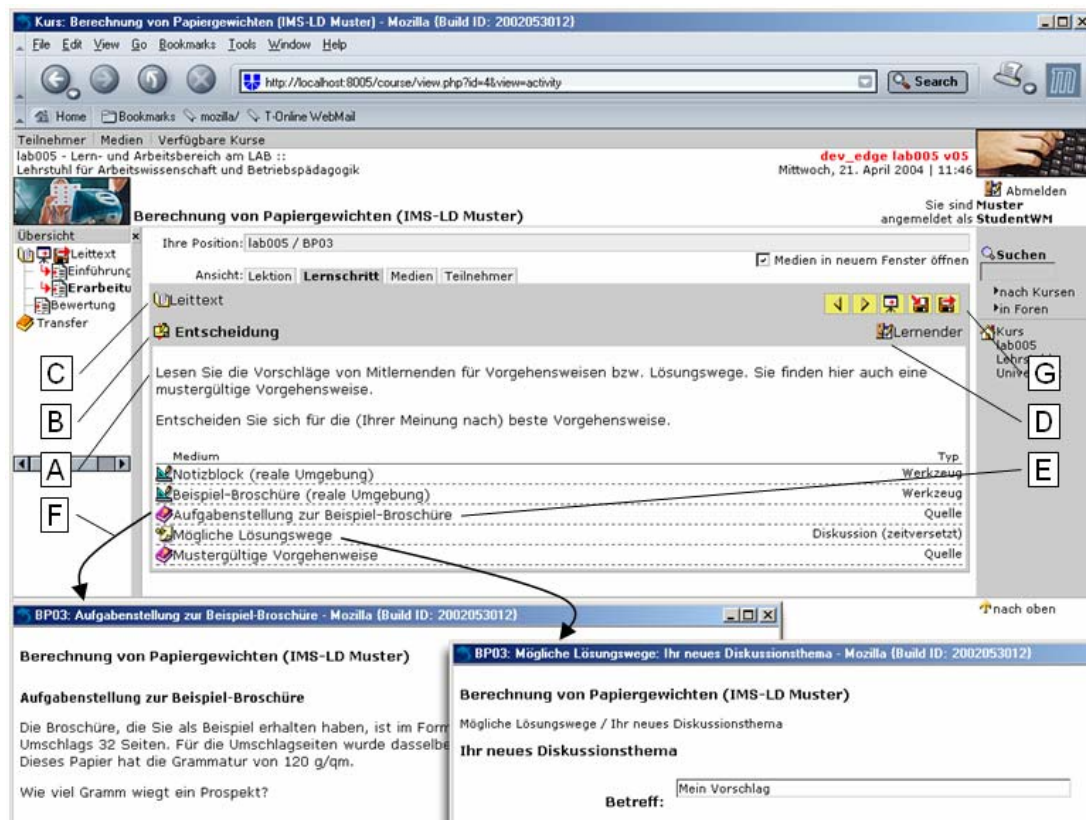


Figure 3. Screenshot of view of single activity in lab005

All elements in the learning environment that are linked to this single activity are listed below it [E]. Thus, both learning objects and services are directly at hand in order to perform a learning activity or supporting activity. They open into new web-browser windows – so they can be used in parallel [F].

A navigation tool [G] that allows browsing back and forth step by step using arrows as buttons is placed on the cue-card. Cue-cards for activities help to structure the process of teaching and learning. They are not meant to restrict activities of learners and interaction between learners and teaching staff. Neither are they used or perceived this way. They are employed as a helpful tool in structuring and comprehending complex interactions in teaching and learning.

List of Elements in the Learning Environment

In IMS Learning Design, learning environments (<imsld:environment>) are an important element to order and structure learning objects and services used in the teaching-learning process. Environments are container elements. Since they can be nested, they can be used to build a hierarchical organisation for learning objects and services. Learning objects and services cannot be assigned to activities directly, so learning environments serve as linking elements between activities and resources for learning. However, learning environments are not only linking elements. Instructional designers may use them to group learning objects and services into packages, in order to reuse these packages and to present them to the learner at a given step in the teaching-learning process.

As the specification suggests (Koper et al., 2003b), the hierarchical organisation of learning objects and services is to be presented to the learner. The LD-player provided by CopperCore (Martens & Vogten, 2005) provides an environment tree that represents all given elements of the learning environment at a given step in the teaching-learning process.

From the viewpoint of a learner, this grouping increases the complexity and appears to be needless. A single learning or supporting activity (itself a leaf node of a hierarchical and sequenced organisation of the teaching-learning process) is considered as the smallest meaningful entity in the unit of learning. Starting from this entity, a learner expects simple and parallel access to all learning objects and services needed to perform an activity. This notion may be enhanced through the metaphor of a cue-card for activities, where these are clearly marked as the smallest entity in the process of teaching and learning. Hence, in the latter versions of lab005 elements in the learning environment are presented in simple, table-like lists. These lists of learning objects and services are found below activity descriptions. A third tab offers access to lists of learning objects and services independently from the activity tree. This list can be used to access learning objects (like texts to read) and services (like discussion forums) directly.

As long as learning objects and services are provided digitally, they can be accessed directly from this list of objects. In the latter versions of lab005 new browser windows opened for them without navigation features. For adaptability, users can choose to open them in the main window (also used when new windows are blocked by the web browser), but mostly new windows are used to access learning objects and services. As a result, the main window is kept as a central navigation device for controlling and observing the teaching-learning process. In this way the separation of process and content in teaching and learning, which is one central concept of IMS Learning Design, is applied efficiently to the graphical user interface.

Markers, Browsing and Navigation

As a graphical user interface for self directed learning, lab005 offered the possibility for users to browse the entire unit of learning. Learners are not taken in rigorous steps from one learning activity to another. On the contrary, they are encouraged to examine the complete unit of learning, mainly to revisit previous phases or activities. In order to allow learners to browse the whole unit of learning and return easily to the current step in the teaching-learning process, three independent markers are needed:

- A first marker denotes the current view of the teaching-learning process while browsing. A single play, act or activity is chosen by the user and displayed, independently from the learning activity currently performed by the learner. Learners can use any view of the teaching-learning process for exploring the unit of learning. A bold font-weight was used to indicate which step is viewed at one moment of interaction.
- Secondly, the learning activity currently performed is marked as in use by a learner. A bookmark such as that used while reading a book was considered, but a symbol for a floppy disk is instead used to indicate the activity currently performed by a learner. Hence, using the symbol for a floppy disk, a learner can save and recall his or her current activity.
- A third marker is used to give information about the position of the whole group of learners, i.e. the class. A user may use this marker to synchronise his or her view to the step in process where the class as a group (or the majority of the learners) has arrived. This position can be set by a teaching person. A whiteboard is used to indicate this specific point in the representation of the teaching-learning process.

Other solutions on marking progress in teaching and learning addressed the differentiation of past and future phases in the teaching-learning process. Past chapters and phases are dimmed, i.e. grey text is used for their titles. Within the list of all learning objects or services for a chapter, only those assigned to a single current activity are displayed in black, while others were dimmed, too. Nevertheless, all resources are still accessible for browsing the whole course. Given this, a learner can access past and future resources for learning quickly without losing focus on the current learning activity.

Those concepts in the graphical user interface provide features to explore the unit of learning in a self-directed way. In our qualitative studies, this possibility of explorative access proved to be a key to acceptance and ease of use.

Outcomes

Considering the above described concepts of a graphical user interface for units of learning conformant to the specification, some conclusions can be drawn on the employment of IMS Learning Design. They mainly concern issues that arise from practical use in mixed mode learning scenarios, hence in classroom teaching.

Classification of Learning Objects

In IMS Learning Design, a classification of elements in the learning environment is suggested. This classification can be done by an attribute `type` for learning objects (`<imsld:learning-object>`). This attribute is not mandatory, nor is an enumeration given. The specification (Koper et al., 2003b) suggests adopting a classification given in the IEEE LOM standard for meta-data (see Learning Technology Standards Committee of the IEEE, 2002). Services are classified as communication service (synchronous, such as a chat, or asynchronous like a newsgroup), as e-mail communication or as an index search.

In developing lab005, we assumed that this classification could support learners while learning. If elements in the learning environment, learning objects and services likewise, are differentiated by symbols, this differentiation should foster the interaction between learner and teaching staff as well as between learner and system. The categories of elements in the learning environment were oriented on IEEE LOM as well as on contextual requirements for the specific units of learning operated with lab005: *resource*, *lecture*, *assignment*, *exercise*, *exam*, *tool*, *simulation*, *problem statement*, *case study*, *asynchronous conference*, *synchronous conference*, and *announcement* were used as resources for learning.

But as a result of the qualitative studies, we observed that a classification of elements in the learning environment and a corresponding coding in symbols or text does not foster learners' comprehension of the teaching-learning process. Noting the function of a resource or service for learning (e.g. *lecture* versus *text*, *tool* versus *simulation* and *assignment* versus *exam*) increases the complexity of the graphical user interface rather than supports a learner.

Learners in interaction with an information system for learning obviously anticipate using digital media or communication devices for learning. In classroom scenarios they use non-digital media and real objects as well. The function of these resources for learning is not a major concern for a learner. A learner expects direct access, especially if he or she is well informed about what to do with a resource by an activity description. Following this idea, a learning activity (or a supporting activity) serves as a wrapper element for learning objects and services in a teaching-learning process. Hence, a description of the function of resources has to be contained in the activity description (implicit or explicit). Further noting in the form of an attribute `type` is redundant and confusing for a learner.

IMS Learning Design in Touch with Reality

IMS Learning Design addresses support for mixed mode (blended learning) as well as for pure online learning (Koper et al., 2003b). Mixed mode learning scenarios imply real life situations in classroom or similar settings, hence direct communication between learners and teaching staff as well as interaction with physical objects like textbooks and tools. For example, in a university course on educational media, a group of learners might be working on a case study where the learners are supposed to outline a concept for a training course introducing a new product. Hence, information brochures about the exemplary company and the product in question, maybe the product itself, are provided as real learning objects. The learners may use sketch pads and a flip chart for their direct communication. While supporting the design process, a teaching person may use a blackboard to note feedback for all groups on issues of group dynamics, creativity and instructional design. Further examples of real life learning scenarios where physical objects are used can be found easily, e.g. in technical courses in higher education or vocational training, where learners regularly use laboratory equipment.

A concept of a 'learning environment' intended to support classroom teaching has to provide facilities to describe physical objects and direct communication. In our practical use of IMS Learning Design in mixed mode higher education, we noticed some difficulties in relation to real life situations. At first, there is a general challenge in referencing from the graphical user interface to real life objects used for learning or to face-to-face situations for communication in class. Users of an information system for learning tend to expect everything to be accessible through the information system itself. Especially with desktop computers, which imply a certain physical setting in the relation of human user and machine, attention is drawn completely to keyboard, mouse and screen. Thus people experience difficulties in interacting simultaneously with the PC and with other persons or objects in real life. With increased usage of mobile devices such as notebooks and PDAs, such problems may decrease. Future application of IMS Learning Design in scenarios of mobile learning will show relevant challenges and solutions.

Nevertheless, IMS Learning Design has to be enhanced further to describe physical objects and direct communication. Of course it is possible to integrate physical objects in a unit of learning as learning objects through a simple description. Also, face-to-face communication settings can be integrated as a type of synchronous conference. However, an attribute is still missing to mark a learning object or a service as not given digitally in the unit of learning and thus existing in real life. This attribute would help to prepare units of learning for runtime through a list of real life objects, which teaching staff has to supply for classroom teaching. If given to the learner through the graphical user interface, this attribute would help to avoid disorientation.

Another cause of disorientation is the combination of learning objects provided in the unit of learning on the one hand and resources linked from outside the unit of learning, i.e. available on the web, on the other. Learners may possibly lose their orientation, particularly if web pages or web-based information systems outside the information system used for learning can be accessed comfortably as learning objects. Hence, elements in the learning environment that lead to external resources should be marked clearly. In conclusion, we suggest three types of availability (*availability-type*) for elements in the learning environment:

- *included* for elements that are digitally integrated in the content package for a unit of learning; thus assets for the unit of learning that are approved and revised resources for learning,
- *real* for elements that are non-digital resources that have to be supplied for classroom teaching or self-study and are used along side the information system that runs a unit of learning, and
- *linked* for elements that are digitally available through the web but not an integrated part of the unit of learning; thus not approved and revised by teaching staff.

For pragmatic reasons, in practical use we consider the attribute *availability-type* far more important than the attribute *type* for a learning object. A compulsory integration would enhance the implementation of IMS Learning Design in mixed mode scenarios.

Complementary Activities in Classroom Situations

As discussed above, mixed mode learning scenarios, which are addressed by IMS Learning Design, imply real life situations in classrooms or similar settings. Regardless of whether we call them tutorials, seminars, lessons or training, in these situations learning activities and supporting activities take place in close relationship: same time, same place. Activities of learners and teaching staff imply immediate interaction, where learning activities and supporting activities are connected in a complementary manner. In common learning scenarios like seminars, lessons or training situations, examples for complementary activities suggest themselves: While a lecturer explicates an issue concerning a subject to learn, learners listen and may take notes. While learners discuss an issue, one person leads the discussion. While learners perform a task for learning on their own or in a group of learners, a tutor will assist and be prepared for questions.

In these teaching-learning situations, specific learning activities imply specific supporting activities and vice versa. In addition to classroom teaching, this also applies to certain scenarios in online learning, where a high degree of synchronicity is given, such as in chats or virtual classrooms. Learning and supporting activities that are closely interrelated we call complementary activities.

In contrast, in online learning, interaction between learners and teaching staff (and, to some extent, interaction between learners and information systems alike) can be described more as a sequence of moves in a game rather than through complementary activities. A typical assignment in higher education can serve as a simple example for this kind of move-by-move approach: In a first move, a tutor addresses an assignment to the learners. In a second move, a learner works on the assignment and submits it back to the tutor as a third move. In a fourth move, the tutor assesses the assignment and provides feedback as a final, fifth move. IMS Learning Design follows the notion of moves in a game in connecting learning and supporting activities to roles in role-parts subordinate to acts. For asynchronous interaction between roles, clear separation of phases in the unit of learning by acts works well. Here, the origin of IMS Learning Design becomes evident: The preceding specification EML (Educational Modelling Language) was developed for online learning scenarios at the Open University of the Netherlands.

But in learning situations in classrooms or similar settings, the description of interactions between learners and teaching staff in role-parts subordinate to acts becomes very complex and redundant. For complementary activities, one activity implies the activity of a counterpart, so only a leading activity has to be described. In order to integrate the notion of complementary activities in real life learning scenarios better, we suggest

introducing an element like activity-situation, which can be assigned to learners and teaching staff at the same time and give a comprehensive description of the direct interaction between both roles.

Conclusion

This article provides an account of the web-based learning environment lab005 implementing basic concepts of IMS Learning Design. As neither runtime environments nor authoring systems were existent when IMS Learning Design was published as a final specification in February 2003, lab005 was built as a prototypical runtime environment for IMS Learning Design extending Moodle, an open source course management system. Several university courses (and an exemplary unit of learning for use in usability tests) have been developed and have been in operation on a regular basis since then.

These courses provided a use case for the empirical review of IMS Learning Design. In terms of usability, one outcome of this evaluation concerns the interaction of users in learning situations with a learning environment for IMS Learning Design. A user-centred evaluation analysed key concepts for a graphical user interface, which represents essential concepts of IMS Learning Design in a meaningful manner to both learners and teaching staff. Key concepts for a graphical user interface addressed useful representation of a hierarchical and sequential organisation of learning (and supporting) activities, representation of single activities, representation of resources for learning and markers in the teaching-learning process. For the representation of the teaching-learning process in an activity tree, a reduction of complexity was gained through separation of three levels of details in aggregation, i.e. a view for the whole course down to phases (i.e. 'acts' in LD terms), a view for a unit of learning down to single activities and a view for a single activity with a list of resources needed to perform this activity. For representing a single learning (or supporting) activity, a cue-card with a simple list of resources, i.e. learning objects and services, proved to be a viable concept. Hence, the notion of an environment tree was abandoned in favour of reducing complexity. Markers for the current view, for the current activity performed by a single user and for the current position of the whole course support learners in self-directed and explorative use of a unit of learning.

As a second outcome of the empirical review, some further conclusions can be drawn on the use of IMS Learning Design in mixed mode learning scenarios (use for blended learning), which mainly concern issues that arise from classroom teaching and similar learning situations, e.g. vocational training. At first, a classification of learning objects by type (e.g. *lecture* versus *text*, *tool* versus *simulation* and *assignment* versus *exam*) is not a major concern for learners and unnecessarily increases the complexity. A differentiation of availability (i.e. included, real or linked) appears to be more helpful. Especially in classroom situations or vocational training, where real objects and direct communication are part of teaching and learning, an indication for a reference to an object or a communication situation outside the web-based learning environment in the real world is essential. Since direct communication in classroom teaching implies complementary activities, where activities of learners are a counterpart to activities of teaching staff and vice versa, a strict division of activities for learners from the activities of teaching staff (in role-parts) leads to a complex and redundant description of the teaching-learning process. A possibility to note these steps in a learning scenario as an 'activity situation' would foster scope and completeness of IMS Learning Design.

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