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Modularization and Structured Markup for Learning Content in an Academic Environment

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This article aims to present a flexible component model for modular, web-based learning content, and a simple structured markup schema for the separation of content and presentation. The article will also contain an overview of the dynamic Learning Content Management System (dLCMS) project, which implements these concepts. Content authors are a key factor for the successful application of these concepts. To support the authors creating modular contents the learning unit development guidelines were developed as part of the dLCMS project. An evaluation of the dLCMS and the guidelines from the point of view of learning content authors in an academic environment and a student evaluation of learning units which are composed of small, self-contained learning components is presented.

Introduction

The basic idea of a *learning object* is it being a small, modular and self-standing chunk of learning content, which flexibly can be assembled into electronic courses (Downes, 2001; Hamel & Ryan-Jones, 2002). Today several learning object repositories give public access to a wide variety of existing learning resources (ARIADNE, 2001; EducaNext, 2004; MERLOT, 2004). The learning objects contained in these repositories come in a variety of types of learning resources (lectures, presentations, reference material, simulations) and data formats (HTML with JavaScript, PowerPoint, Flash, Java, etc.). Most of the learning objects are individually designed and styled,

and navigational and user interface controls are directly integrated into the learning objects. Aggregating such learning objects from different origins to larger coherent learning units is hardly possible, due to inconsistencies in the graphical and navigational design. To overcome these problems Duval states that "a more sophisticated component oriented model … that will enable seamless integration of document fragments from diverse origins" as well as "the separation of content, presentation" is needed (Duval, 2004).

The *dynamic Learning Content Managemen System (dLCMS)* projects provides an implementation of a simple and flexible component model, and defines a standard level of granularity based on *didactic content types*, such as examples, exercises, self assessment, etc. As a flexible data format for the learning contents contained in the components, the dLCMS also specifies a simple XML-based structured markup schema to separate contents and presentation. In the following, the dLCMS content model and structured markup scheme as well as the functional architecture of the system are briefly outlined. Then we present the *learning unit development guidelines*, which aim at supporting authors to create modular contents for the dLCMS. An evaluation of the component model, the structured markup schema and the development guidelines from the point of view of learning content authors in an academic environment and a student evaluation of learning units which are composed of small, self-contained learning components is presented. The last section of this article will contain our conclusions on the work presented.

Component Model

In order to be able to successfully aggregate learning objects from various origins to larger learning units, these objects must have similar *granularity* and they must be *self-contained* (ADL, 2001; Chitwood, May, Bunnow, & Langan, 2000; Hamel & Ryan-Jones, 2002; Polsani, 2003). Unfortunately there is no generally accepted specification for granularity. A level of granularity proposed by many researchers is to base learning objects on a single *learning objective* (Barritt & Lewis, 2000; Baruque & Melo, 2003; LSAL, 2003). Another approach to a level of granularity supporting reuse might be based on *didactic content types* (e.g., definition, example, exercise, simulation, self assessment, etc.) (Schulmeister, 2003). A *didactic content type* may be seen as a piece of learning content which relates to one of Gagné's nine instructional events (Gagné, 1985).

A good example to show how *didactic content types* can be combined to serve different learner groups' needs is the subject matter of statistics. Students of pedagogy, medicine, psychology, sociology, and economics need to learn the same theoretical concepts, definitions and principles. Therefore a learning object representing a definition, (e.g., for the "standard deviation") can be reused for students of different disciplines. However examples,

which are used to illustrate the theoretical concepts, should apply to the domain familiar to the student – one might want to present a patient population in medicine, while enterprise performance data will suit the needs of students in economics better. Using *didactic content types*, we can flexibly combine components with a high potential for reuse together with elements which apply to a scientific discipline more specifically.

Our learning content component model defines three component types: *assets, content elements*, and *learning units* (see Figure 1).

Assets are media elements such as images, videos, animations, simulations, etc. They are basically binary data objects, which cannot easily be divided into smaller entities. Generally they contain pictorial or auditory information, which can be static (image, graph) or dynamic (video, audio, animation). Further they can be interactive programs to be embedded into *content elements*.

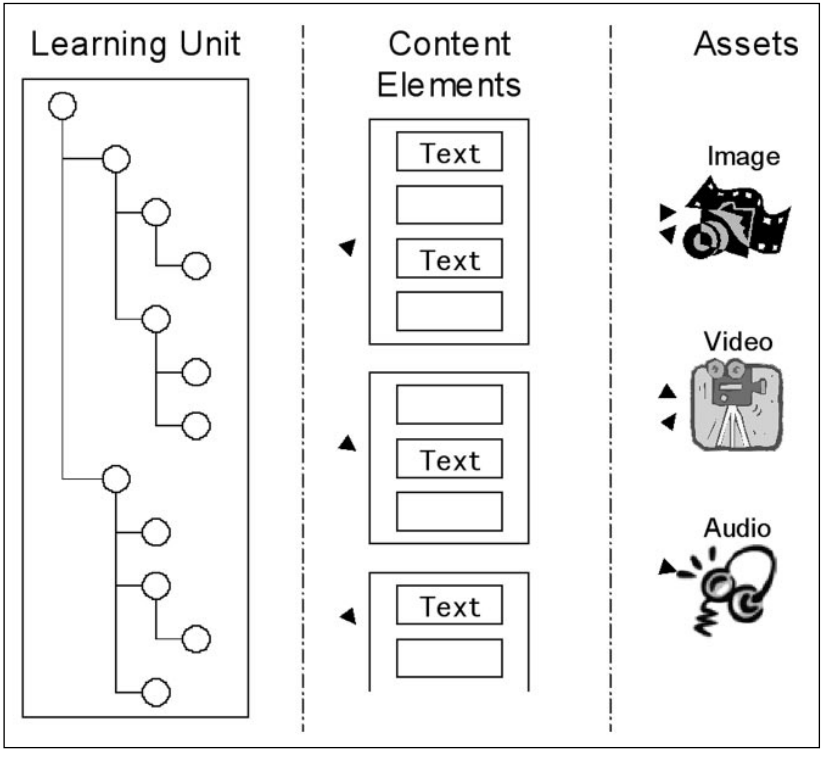

Figure 1. Component model consisting of assets, content elements, and learning units

Content elements are defined as small, modular pieces of learning content, which: (1) serve as basic building blocks of learning content, (2) can be aggregated to larger, didactically sound learning units, (3) are self-contained, (4) are based on a single *didactic content type*, (5) are reusable in multiple instructional contexts, and (6) may contain *assets*. We propose that a content element comprises a single didactic content type because of the anticipated higher potential of reuse, and the hope that this will promote the development of content elements with a similar level of granularity. A content element is designed as a single webpage. The page length is not fixed. Being a single page, content and navigation are consequently separated. The navigation structure will solely be defined by the aggregation into *learning units*.

We define a *learning unit* as an aggregation of *content elements*, which is presented to the learner. Typically a *learning unit* serves as an online lesson and may be used to teach several learning objectives. A *learning unit* provides a way to define a chapter-like, hierarchical structure of nodes. Each node will be associated to a *content element* through reference. The *content elements* are not copied into the *learning unit* but are referenced by links. At the moment, our component model does not define any further level for the aggregation of *learning units*.

Structured Markup

Generally structured markup is used in order to separate contents from presentation and navigation. Although HTML is a widely accepted markup standard, it allows content creators to mix structured markup with graphical styling thus not truly separating content and presentation. XML, too, is a markup language for contents containing structured information. Other than HTML, no specific set of elements is specified. XML provides means to define markup schemas, which will be well adapted to the structure of specific types of information (Walsh, 1998). This allows a specification of markup which designates the type of content in a meaningful way. For example, a markup schema for learning content could specify tags assigning the didactic purpose to the content. In the past some work has been done to define specific XML-schemas for learning content (Rawlings, Rosmalen, Koper, Rodriguez-Artacho, & Lefrere, 2002; St-Pierre, Hope, & Skublics, 2002). But up to now no proposed schema could be established as a basis for further standardization.

We propose to define the data structure of *content elements* by an XML *structured markup* schema and a set of *metadata* elements. The schema is simple, based on standard typographical elements, such as headers, paragraphs, list, and tables. As a *content element* should comprise only a single *didactic content type*, didactic information can be assigned to the content element as a whole using didactic metadata. The structured markup schema thus contains block elements (headings, paragraphs, annotations, lists, tables, images, multimedia elements) and inline elements (strong, emphasis, under-

line, superscript, subscript, links). Using standard typographical elements, the schema is anticipated to be familiar to content authors. Further, contents using this schema are likely to be easily convertible to possible future data formats. The markup schema remains stable, even if new didactic content types are needed – new types can flexibly be assigned using metadata.

The dLCMS Project

The *dLCMS* project aims at providing an implementation of the *component model* and the *structured markup schema* described above. It provides functionality for *flexible aggregation* of content elements to learning units, *centralized content management* which allows authors and teachers to collaboratively use and reuse learning resources, *flexible graphical design* through layout templates, and *export of learning units* in standardized packaging formats such as IMS Content Packaging (IMS, 2004) and SCORM (ADL, 2001). Authors shall be able to create contents using structured markup concentrating on their subject matter and without having to care about programming languages and graphical design issues.

The dLCMS functional architecture is based on four main components (see Figure 2). An *online editor* enables authors to create structured markup for content elements, without having to care about programming languages and graphical design issues. The *centralized repository* provides easy access to the learning resources. The *learning unit assembly* stage allows content elements to be aggregated in a sequential or hierarchical, chapter-like manner. The *publishing and export* stage provides flexible graphical styling using layout templates and an export function for learning units delivering standardized packaging formats.

The dLCMS is an extension of the open-source Silva content management system (Infrae, 2005). The main reasons to choose Silva as a basis for the implementation of the dLMCS were the integrated online XML editor and the extendibility of the open-source software product.

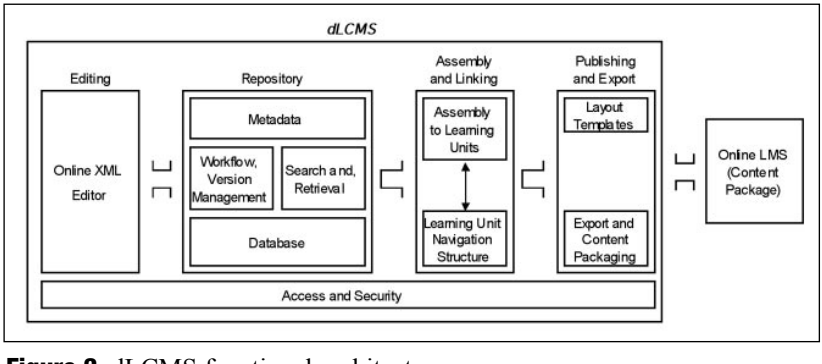

Figure 2. dLCMS functional architecture

Learning Unit Development Guidelines

Learning objects are a new way of thinking of learning content. Authors of learning resources might need guidance to adapt their thinking of learning material, which traditionally had been whole courses or lecture notes (Chitwood et al., 2000; Polsani, 2003). In order to support content authors to create self-standing learning objects, the "SCORM Best Practices Guide for Content Developers" (LSAL, 2003) suggests to start with an instructional strategy or with existing material and then to identify the learning objects based on learning objectives and on an analysis of the potential audiences. But it is still left open which level of granularity learning objects should have. The ISMELDO methodology to create learning objects (Baruque & Melo, 2003) is based on Instructional System Design (ISD). Using a top-down approach, the methodology analyses the task and contents to be taught and breaks the contents down into different "elaboration levels." Here learning objects are based on learning objectives and contain multiple didactic content types.

As in our case, content elements are based on single *didactic content types*, we have developed *learning unit development guidelines*, which should help authors to chunk learning content accordingly. In order to support the chunking process and the assembly of *content elements* to *learning units*, the *design* and the *development* phase of the general ISD model were extended. Thus our learning content development process can be divided into seven phases: *learning unit (LU) analysis, LU concept, content chunking, LU assembly, teaching,* and *evaluation* (see Figure 3).

Special attention was given to the modularization process, which was defined using a three step procedure:

1. First the content should be broken down into topics and subtopics, each of which is centered around a single objective. As a help to identify single objectives, the items should be labeled by their *knowledge type (concept, fact, procedure, process, and principle)*.

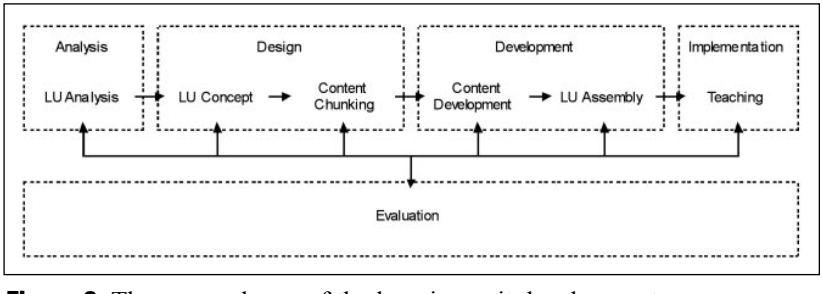

Figure 3. The seven phases of the learning unit development process: learning unit (LU) analysis, LU concept, content chunking, LU assembly, teaching, and evaluation

2. Then the *didactic content types* to be used should be assigned to every topic or subtopic. For every single *didactic content type* a separate *content element* should be created.
3. At last three to five other potential learner groups for the subject matter should be identified. The *content elements* specified so far should be analyzed for reuse with the potential learner groups. If only some parts of a *content element* fit the needs of a group it should be considered to divide it into two or more pieces.

Evaluation with Learning Content Authors

We have committed an evaluation of the *dLCMS* and the *learning unit development guidelines* described above, focusing on modularization and structured markup. The following questions guided this research: (1) Do authors understand the concept of modularization? (2) Can authors be supported by the guidelines to create modularized content? (3) Can small, self-contained *content elements* be aggregated to didactically coherent learning units? (4) Are specialized didactic content types and markup needed? (5) Do authors perceive structured markup as an aid or as constraint to creativity?

Authors from three different scientific domains (natural sciences, social sciences, engineering sciences) as well as one author working in the ICT services department of an academic environment used the *dLCMS* to create a web-based learning unit for the education of students or university personnel. The authors' task was the development of a *learning unit* used to teach a topic of their knowledge domain. The participants were free to choose the didactic strategy and methods, which they believed would suit their purposes best.

Preliminary analysis suggests that the proposed steps to modularize content described in the guidelines did not work well. The assignment of *knowledge types* was difficult and the analysis for other potential learner groups did not have any effect on the modularization structure. Anyway the participants reported that the guidelines would improve the didactic quality of the *learning unit*, having a structuring effect on the planning of the learning unit and the singular elements. Generally the participants were able to create modular, self-standing *content elements*, suggesting that they did understand the concept of modularization. These *content elements* could be aggregated to larger learning units, which corresponded with the authors expectations. In a few cases the participants stated that it should be possible to combine several *content elements* on a single page. Markup elements reported as missing concerned mainly specialized markup for literature and glossaries. Further, markup for multiple-choice like questions were missing. No author perceived the structured markup as constraining creativity.

Student Evaluation

One of the learning units created above was also evaluated by students. The driving question of the evaluation was: Do students perceive *learning units* which are based on modular *content elements* as didactically coherent? The *learning unit* was an introduction to usability evaluation and was used to teach students of an post-graduate study in ergonomics. A questionnaire, containing 17 items on students' previous computer and e-learning experience and on the didactic quality of the *learning unit*, was handed out to the students after they have worked with the *learning unit*. The results of the investigation were analyzed using descriptive statistics.

As a result, the students were able to easily detect the logical relationship between the pages. Therefore it may be concluded that it is possible to aggregate self-contained *content elements* to a larger coherent *learning unit*. The results further suggest that it is possible to provide a good didactic quality, provided that such a *learning unit* makes use of the advantages that e-learning can offer, such as the use of multimedia and elaborate interactive elements, and the possibility to learn anytime and anywhere. Further, modularized contents may yield to a good comprehensibility of the contents and a clear structuring of the subject matter. As the investigation looked at only one *learning unit*, which was specially developed for this instructional context by a single author for a specific target learner group, further research will be needed to generalize these findings.

CONCLUSIONS

The *dLCMS* provides an implementation of a simple and flexible component model based on three component types: *learning units, content elements*, and *assets*. *Content element*, comprising single *didactic content types* may provide a basis to define a standard level of granularity which, together with a structured markup schema based on standard typographical elements, allows contents from different sources to be coherently aggregated to *learning units*. The benefits of such a system allows different authors and institutions to define a corporate styling of their e-learning courses, even if the original contents come from sources all over the world.

The evaluation suggests that content authors in an academic environment understand the concept of modularization and that they are able to create modular building blocks of learning content which can be aggregated to larger *learning units*. It should be considered to provide possibilities to combine multiple *content elements* on a single page. The simple structured markup schema seems to be sufficient, provided it contains markup elements for literature references, and glossary entries. A separate markup schema for self-assessments and tests is desirable, it could be based on the IMS Question & Test Interoperability specification (IMS, 2005). In the content, authors opin-

ion a good modularization methodology enhances the didactic quality of the *learning unit* and therefore pays-off. However further research is needed to provide better support for authors to create modular contents.

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