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MODULARIZATION AND STRUCTURED MARKUP FOR WEB-BASED LEARNING CONTENT IN AN ACADEMIC ENVIRONMENT

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Foreword

The development of multimedia learning contents is time-consuming and expensive. Accordingly, the question raised at the beginning of every new e-learning project is whether elements of existing learning materials can be reused for a new educational context. But what are the requirements to produce truly reusable learning contents? The idea of using the flexibility and the power offered by computers today is very appealing, not only for the presentation of multimedia e-learning materials, but also for the management of such data. This concept, however, is not just related to technological problems. It also implies a new way of thinking about learning material that has consequences on the management of learning contents and possibly has an impact on the didactics and thus on the teaching as well. On the one hand, content management that supports the reuse of learning material may constrict the way learning contents are designed, but on the other hand, it may open up new possibilities that go beyond traditional linear structured textbooks. The XML technology allows for the separation of content and graphical layout which offers an interesting approach for the implementation of reusable learning contents.

The problems to be solved are well described by the following questions: Which are the relevant characteristics of learning materials that ensure their flexible reuse in various educational situations? The question certainly does not solely rest with the storage and retrieval of electronic learning materials. An important aspect in this case is the granularity of the contents. Small grained learning objects designed to be independent of a specific educational context are easier to reuse than large modular units. But how can contents be broken down into such elementary, “atomic” learning objects? For this purpose a model is needed which takes into account the way authors think about elementary learning content entities and the way teachers would handle such reusable materials. The contents may have been created by the teachers themselves or collaboratively with other authors. We may generally ask if it is possible to identify elementary learning entities which are suitable to be modularized and stored in an appropriate format and which can be retrieved from a learning content management system for reuse in diverse educational contexts.

Despite the many standardization activities in the field of e-learning, the great number of published learning objects today integrate contents, layout, navigation, and user interfaces, all of which are tightly intertwined. This results in learning objects that provide a particular presentation format for a specific educational context and thus prevent their reuse in varying learning contexts.

The present work is a successful approach to modularize learning contents, as described above, in order to produce learning objects which are completely self-contained. The key idea is the separation of content and layout which is the basic requirement for such elementary learning objects to be universally reusable. The main contribution of the learning content management system (LCMS) presented in this work is the implementation of a consistent modular learning object component

model and the consequent separation of content and graphical presentation. It enables flexible composition of singular learning objects to a complete and didactically coherent learning application.

The author provides a substantial overview of the actual state of the art of development methods for e-learning materials and their underlying concepts. These methods establish a solid foundation for the powerful “dynamic Learning Content Management System” (dLCMS). The presented studies of initial e-learning projects using the dLCMS show the possibilities and limitations from the point of view of teachers and, above all, reveal its great potential for future development. Actually, the support to create self-contained, modular learning objects which separates content, graphical presentation, and didactics is a fundamental advantage of the LCMS presented here.

Hence, this work pursues the really simple idea, that it should be possible to create small and modular learning objects which separate content and graphical presentation and which can be aggregated into larger didactically coherent lessons and courses. As a proof of the significance of this idea, four case studies from diverse fields of academic teaching are presented.

The dLCMS, which is based on clear theoretical concepts and has been evaluated in the field, is undoubtedly worth follow-up by way of future research and development. The author’s conceptual model is a significant contribution to the ongoing debate about the possibility of interweaving e-learning materials originating from differing sources.

Zürich, May 2005

PD Dr. Sissel Guttormsen Schär

Prof. Dr. Dr. Helmut Krueger

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Abstract

The basic idea of a *learning object* is that it is a small, modular and self-standing chunk of learning content, which can flexibly be reused and assembled to electronic courses. Today, learning objects 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 objects. This phenomenon prevents a coherent assembly into larger learning units due to the inconsistencies in the graphical and navigational design.

In order to be able to successfully assemble learning objects from various origins into larger learning units, these objects must have similar *granularity* and they must be *self-contained*. Further, a standard data format separating contents from their visual presentation and navigation is needed. *Learning object component models* define different levels of granularity and specify how the components can be aggregated. *Structured markup*, using XML-based languages, provides a means to separate contents and visual presentation. The present work investigates learning object component models, the process to create modularized learning components, and structured markup for web-based learning contents.

The *dynamic Learning Content Management System (*dLCMS*)* project, presented in this work, defines and implements a learning object component model and structured markup. The level of granularity proposed is based on, what we call, *didactic content types* (e.g. definitions, examples, exercises, simulations, self-assessments). The suggested basic structured markup schema uses traditional typographical elements such as headings, paragraphs, lists, tables, etc. Because of its simplicity, it is anticipated to be easily understood by content authors and to be readily convertible to possible future data formats. The dLCMS provides a separate markup schema for questions and tests.

Content authors are a key factor for the successful application of these concepts. To support the authors to divide contents into learning objects representing a single didactic content type, the *Learning Unit Development Guidelines* have been developed as part of the dLCMS project.

A qualitative evaluation of the dLCMS and the *Learning Unit Development Guidelines,* together with content authors in an academic environment, focused on the modularization of learning contents and the application of structured markup. Authors from three different scientific domains (natural sciences, social sciences, engineering sciences) and one author working in the ICT services department 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 to teach a topic from their respective knowledge domain. The participants were free to choose the didactic strategy and methods which they believed would best suit their purposes. Additionally, a student evaluation of a learning unit composed of small, self-contained learning components was conducted. The evaluation investigated whether or not students perceive such learning units as didactically coherent.

As a result of the evaluation, it can be concluded that content authors in an academic environment generally understand the concepts of modularization. They are able to create self-contained modular building blocks of learning content which are based on didactic content types. However, the authors need support to divide learning content into learning objects representing a single didactic content type. Further research is needed to improve the *Learning Unit Development Guidelines*.

These findings suggest that the process of creating such learning objects may foster the didactic quality of the whole learning unit. The analysis of the contents with respect to the didactic content types helps authors to clearly structure the subject matter into small comprehensible learning steps.

The simple structured markup schema has been found to be sufficient, provided it contains markup elements for literature references and glossary entries. The approach to provide a separate markup schema for questions and tests is feasible, but the schema provided needs to be improved.

The results of the student evaluation show that students are able to easily detect the logical relationship between the self-contained learning objects in a learning unit. Thus, it may be concluded that it is possible to aggregate self-contained learning objects into larger didactically coherent learning units.

Hence, the dLCMS provides a simple and flexible component model. The granularity level of the basic building blocks is based on didactic content types which may be a basis to define a standard level of granularity. Together with the structured markup schema using standard typographical elements, and a schema for questions and tests, this framework allows contents from different sources to be coherently aggregated into learning units. As a benefit of such a system, different authors and institutions can define a corporate styling of their e-learning courses, even if the original contents come from sources from all over the world. However, it remains to be seen whether or not the *reusability* of e-learning contents will be improved in practice using such a framework.

Zusammenfassung

Learning Objects sind kleine, modulare Lernbausteine, die flexibel wiederverwendet und zu elektronischen Kursen zusammen gestellt werden können. Heute verfügbare Learning Objects verwenden unterschiedlichste Datenformate (HTML mit JavaScript, PowerPoint, Flash, Java, usw.) und repräsentieren unterschiedliche Arten von Lernmaterialien (z.B. Vorlesungen, Präsentationen, Vertiefungsmaterial, Simulationen). Die meisten Learning Objects sind individuell gestaltet und integrieren z.T. Navigation und Bedienungselemente. Die individuelle Gestaltung des grafischen Designs und der Navigation, sowie die unterschiedliche Grösse verhindern, dass solche Objekte zu grösseren, kohärenten Lerneinheiten zusammengestellt werden können.

Um Learning Objects unterschiedlichster Herkunft problemlos zu kombinieren, müssen diese eine ähnliche Grösse (*Granularität*) haben und *in sich selbst abgeschlossen* sein. Ferner wird auch ein standardisiertes Datenformat benötigt, das die Inhalte unabhängig von der grafischen Darstellung und der Navigation speichert. Sogenannte *Learning Object Component Modelle* definieren unterschiedliche Komponentenebenen und sie spezifizieren wie die Komponenten zu grösseren Einheiten zusammen gefügt werden können. *Strukturiertes Markup*, basierend auf XML, ermöglicht die Trennung von Inhalt und Darstellung. Die vorliegende Arbeit untersucht Learning Object Component Modelle, den Prozess zur Herstellung solcher modularisierter Lernkomponenten und strukturiertes Markup für web-basierte Lernmaterialien.

Das Projekt *dynamic Learning Content Management System (dLCMS)*, das hier vorgestellt wird, spezifiziert und implementiert ein Learning Object Component Modell und strukturiertes Markup für Lernmaterialien. Die vorgeschlagene Grösse der wiederverwendbaren Grundbausteine basiert auf *didaktischen Inhaltstypen* (z.B. Definitionen, Beispiele, Übungen, Simulationen, Selbsttests, usw.) Das strukturierte Markup-Schema für darstellende Lerninhalte verwendet die üblichen typografischen Elemente, wie Überschriften, Absätze, Listen, Tabellen, usw. Wegen seiner Einfachheit ist zu erwarten, dass es für Autoren leicht verständlich und einfach in allfällige zukünftige Formate zu übertragen ist. Für Multiple-Choice-Fragen bietet das dLCMS ein separates Markup-Schema an.

Die Autoren von Lerninhalten sind ein Schlüsselfaktur zur erfolgreichen Umsetzung dieser Konzepte. Deshalb wurden die *Learning Unit Development Guidelines* als Teil des dLCMS Projektes entwickelt. Diese sollen die Autoren unterstützen, Lerninhalte in kleine, in sich abgeschlossene Learning Objects zu unterteilen, die einen einzelnen *didaktischen Inhaltstyp* repräsentieren.

Eine qualitative Evaluation des dLCMS und der Learning Unit Development Guidelines mit Autoren in einem akademischen Umfeld untersuchte den Modularisierungs-

prozess und die Anwendbarkeit von strukturiertem Markup. Autoren aus drei verschiedenen wissenschaftlichen Disziplinen (Naturwissenschaften, Sozial- und Geisteswissenschaften, Ingenieurwissenschaften) und eine Autorin der ICT Dienste verwendeten das dLCMS, um jeweils eine web-basierte Lerneinheit aus ihrem Gebiet für die Schulung von Studenten und Personal zu entwickeln. Die Autoren waren frei in der Wahl der didaktischen Strategien und Methoden. Weiter wurde eine Lerneinheit, bestehend aus kleinen in sich selbst abgeschlossenen Learning Objects, von Studierenden evaluiert. Diese Evaluation untersuchte, ob die Lerneinheit als didaktisch kohärent wahrgenommen werden kann.

Aus den Ergebnissen der Untersuchung kann gefolgert werden, dass die Autoren in einem akademischen Umfeld die Konzepte der Modularisierung im Grossen und Ganzen verstehen und in sich selbst abgeschlossene, modulare Lernbausteine auf der Basis von *didaktischen Inhaltstypen* entwickeln können. Aber sie benötigen dazu gute Unterstützung. Weitere Forschung ist nötig um die Learning Unit Development Guidelines zu verbessern.

Die Resultate legen den Schluss nahe, dass der Prozess zur Erstellung von Learning Objects die didaktische Qualität der gesamten Lerneinheit fördert. Die Analyse der Lerninhalte zur Identifizierung der *didaktischen Inhaltstypen* unterstützt die Strukturierung des Lernmaterials in kleine, gut verständliche Lernschritte.

Unser Ansatz, ein einfaches Markup-Schema für darstellende Inhalte anzubieten, wurde durch die Ergebnisse bestätigt, vorausgesetzt das Schema enthält auch Elemente für Literaturreferenzen und Glossareinträge. Es konnte auch gezeigt werden, dass ein separates Schema zur Erstellung von Multiple-Choice Fragen ausreicht; das von dLCMS angebotene Schema muss jedoch verbessert werden.

Die Evaluation einer Lerneinheit durch Studenten hat gezeigt, dass diese den Zusammenhang einzelner in sich abgeschlossener Learning Objects in einer Lerneinheit leicht erkennen können. Daraus kann gefolgert werden, dass in sich abgeschlossene Bausteine zu didaktisch kohärenten Lerneinheiten zusammen gefügt werden können.

Mit dem dLCMS steht ein System zur Verfügung, das ein flexibles Learning Object Component Modell und strukturiertes Markup integriert und es erlaubt Lerninhalte aus unterschiedlichster Herkunft zu kohärenten Lerneinheiten zusammen zu fügen. Die *didaktischen Inhaltstypen* bilden dabei ein Mass, um eine Standardgrösse der Grundbausteine zu definieren. Dadurch können Autoren und Institutionen ihre elektronischen Kurse in einem einheitlichen Erscheinungsbild publizieren, selbst wenn Materialien aus unterschiedlichsten Quellen verwendet werden. Dass in der Praxis die Wiederverwendung von Lernmaterialen mit einem solchen System wirklich verbessert wird muss jedoch noch gezeigt werden.