Supporting the Composition of Micro-Modular Content to Mathematical Learning Modules

Karin Landenfeld, Thomas Preisler, Wolfgang Renz, Peter Salchow

Faculty of Engineering and Computer Science, Hamburg University of Applied Sciences, Berliner Tor 7, 20099 Hamburg, Germany

Abstract

For reasons of authenticity, didactic concept and domain-specific content, lecturers at universities want to use their own manuscripts. Therefore, the common lecturer needs support in generating light-weight digital courses by enriching their manuscripts with reusable micro-modular learning objects. Large amounts of interactive visualizations and animations (Flash, Java applets etc) are reusable for this purpose. In this paper, we address this need, propose an easy-to-use solution and show a first prototype supporting a social network of lecturers using multimedia learning objects particularly in mathematical learning modules.

Introduction

Originally, e-learning platforms (learning management systems, LMS) were developed for pure e-learning situations as typically met in companies, public institutions or distance universities. They provide most of the functionality needed by the course instructor and course participants, e.g. learning paths, wikis, calendars and forums. Nowadays these e-learning platforms have also emerged as a standard tool in universities with their typical mixed learning situations, i.e. digitally assisted attended course, so-called "blended learning", in order to increase learner support. Thus, several commercial (e.g. Blackboard (Blackboard Inc., 2010)) as well as open-source platforms (e.g. Moodle (Al-Ajlan and Zedan, 2008), LON-CAPA (Kortemeyer and Cruz, 2009)) have found their way into the service centres of universities.

Creation of digital courses, i.e. e-learning contents, is usually expensive and therefore the number of learners during the course live-time serves as an economic measure for the usage of a course. At Universities, most professors develop their own courses with a specific didactic concept for a specific application domain. Admittedly, the use of a digital course developed by a professor – author and lecturer in one person – is usually restricted to the lectures held by this professor and co-workers.

Without referring to actual data, fig. 1 shows the typically expected reuse statistics of digital content. Complete courses or course parts obey a strongly peaked distribution indicating the above described situation. Therefore, best candidates for maximizing the course usage are first and second year courses in classical slowly-evolving subjects with high numbers of learners. Experiences with such application situations are the topic of several recent e-learning publications (Jungic, Kent and Menz, 2006). In German Universities of Applied Sciences, student groups with the number of participants limited to 50 to 80 and several different lecturers for the same course are the central educational policy characterizing this type of universities. Thus, an increase of content usage requires other methods.
Figure 1. Typically expected reuse statistics of digital content broken down into lecturing persons using that content. White color code indicates a small number of learners while dark red indicates economically desirable high learner numbers.

Further increase in usage of digital content can be achieved by modularizing content into learning objects (LO) that have to be constructed with the intention of high reuse – a great domain for transferring architectural ideas from software engineering to content engineering. In fig. 1, the improvement of content reuse by modularization is shown in particular for micro-modal LOs like interactive visualizing gadgets typically implemented as flash or applet and wrapped with metadata for use in a content management system (CMS). Technically, course creation tools have to be distinguished from content creation tools like text, image or flash creators. Course creation tools generate the course view and provide means for navigating through the course contents. They are often called Learning CMS (L-CMS) and provide course contents as LO repositories for online publishing. While browsing through pre-generated content the course author is enabled to select and place these contents into the course. Typically these L-CMS are intended for use by course authors (Krämer and Han, 2009) and are too sophisticated for practical use by the common lecturer.

In this paper we assume that lecturers want to use their own manuscript for reasons of authenticity, didactic concept and domain-specific application examples and exercises etc. In order to increase usage of LMS we want to support the common lecturer in generating light-weight digital courses by providing tool support for enriching their manuscripts with reusable micro-modal LOs without learning paths (in agreement with the constructivism). This way we support a university-wide network of lecturers who exchange their materials and LOs, a topic of recent interest (Han et al., 2008).

The rest of the paper is organized as follows: In the next section we will depict the actual problems of teaching mathematics at our university. To compensate that deficiency we propose our approach in the subsequent two sections. The last section
gives a technical overview of the software tools that have been developed as a first solution.

**Situation and Actual Problems**

Mathematics courses form the basis of technical study courses at the Faculty of Engineering and Computer Science at the Hamburg University of Applied Sciences. The study success rate indicates several problems in mathematics courses whose analysis exhibits many possible influencing factors that are only slightly different for different study courses. Most relevant such factors are

- lack of interest in mathematics,
- lack of focus on the application domain,
- no compulsory exercises in some courses,
- incomplete coverage of the subject because of different lecturers,
- pure formula-oriented lectures discouraging engineering students.

Increasing the success rate in mathematics is a key contribution to enhancing the overall study success rate.

**Objectives of the approach**

As a result of cause analysis we propose an activating e-learning environment for mathematics courses which is described below. This approach supports students as well as lecturers in preparing and presenting the mathematical contents. It is based on micro-modular LOs which can be aggregated easily to mathematical learning modules. The activating online environment for engineering mathematics courses should contain the following components:

- interactive visualizing gadgets for supporting comprehension
- online-exercises with solution hints depending on results
- tests for verification of learned knowledge
- application examples with subject specific problems for the course of study
- the lecturer’s script
- exercises matching the current lecture material with links to the above mentioned visualizing gadgets

The content should be made available for the learners on an e-learning platform. Interactive visualizing gadgets and sample applications are required to assist the mathematical understanding for subject-specific problems. Communication should be improved. The online availability enables independent learning and improving lecture materials at every time and every place. These objectives will improve the learning conditions and the learner’s motivation.

**Modular Conception**

The compilation of lecture materials to mathematical learning modules should retain the individuality and authenticity of a lecturer. The modular conception will support the lecturer in the composition of lecture materials, which are important for his specific lecture. Interactive visualizing gadgets, exercises and tests as well as the sample
applications are to be provided for the lecturer, so he can choose the necessary content for his lecture. These micro-modular LOs should be arranged thematically in a web application.

The presented concept explicitly abstains from the allocation of mathematical lecture materials in form of a learning path, like it is handled in other e-learning environments (e.g. MUMIE System (integral-learning GmbH, 2009)). In our approach the lecturer supplements the prepared interactive contents with his own manuscripts to preserve the lecturer’s individuality and authenticity. Since none of the existing solutions support the here presented concept the development of the proposed solution has become necessary.

Figure 2. Concept for composition of micro modules.

Fig. 2 clarifies the above mentioned concept. From a set of pre-composed mathematics module templates, the lecturer selects one specific template according to the topic of his course. Out of this template a mathematics module is generated. In a second step the lecturer completes the module with his own script. The lecturer can rearrange the structure of the module and also add and remove LOs. The final module can be exported to an LMS.

**Techniques and Tool-Support**

The Hamburg University of Applied Sciences has decided to use Moodle as the central LMS. So our approach is to export the mathematical learning modules to Moodle. Therefore our goal is the development of a tool suite to assist the teachers in the creation of their Moodle courses.

One type of micro-modular content, which we want to compose are the so called Mathlets. Mathlets are small Java-Applications (Applets) to visualize and test mathematical topics. Mathlets are developed using a Java library called MathletFactory, which is a part of the MUMIE System (integral-learning GmbH, 2009).
Our first approach to reach the previously described concepts was to implement the MOO-System (Mathlet Online Organization) for storing and managing Mathlets.

Figure 3. A screenshot of MOO with a started Mathlet.

MOO organizes Mathlets in logical categories and enriches them with metadata. Therefore the Mathlet and its metadata are combined in MathUnits. The metadata is composed of textual data (e.g. title and description), a screenshot of the Mathlet and structural information. The screenshot helps the user to get a first impression about the Mathlets appearance and improves the recognition value. There exist several points of view on a Mathlet, so one Mathlet may be assigned to more than one category. Categories themselves are structured hierarchically. This hierarchically structure offers a compact view, which consequently enables the user to navigate easily through the Mathlets. The categories and the contained Mathlets can be filtered using the search function. The search function uses all available textual metadata of a Mathlet. The metadata is not only used for the search function, but also to give the user information about the purpose of a Mathlet. To explore the whole functionality of the Mathlet it can be executed in place as shown in Figure 3.

MOO follows a wiki-like approach. All the metadata, the categories and also the assignment of Mathlets to categories can be edited by the users. As pointed out earlier there are several points of view on a Mathlet. Every user can contribute his/her personal point of view (keywords, description, categories) to the data base. This supports other users in the process of finding the appropriate Mathlet. To avoid the loss of information by intentional or unintentional data manipulation MOO keeps track of all changes by
creating versions. All versions are annotated with the editing user. If necessary users can rollback to any previous version so no information is ever lost.

While navigating through the Mathlets users can collect them like goods in a shopping cart (step 1). From this cart the Mathlets can be exported to the users Moodle course(step 2) as described in section “Objective of the approach”. This simplified workflow is shown in Figure 4. To export Mathlets MOO uses web services to connect to the central Moodle platform on behalf of the user. The application then displays the user a list of his courses in Moodle. The user then selects a category within the list of courses to which the Mathlets from the cart should be added.

Figure 4. Mathlet Online Organisation(MOO) – simplified workflow

MOO was developed as a Rich Internet Application using Google WebToolkit (GWT), it runs on a Tomcat 6 web container and all the data is stored in a MySQL Database. All used technologies are open-source.

References


