[HHRSt05] *Stephan Hörmann, Tomas Hildebrandt, Christoph Rensing, Ralf Steinmetz;* **ResourceCenter - A Digital Learning Object Repository with an Integrated Authoring Tool Set;** ED-MEDIA 2005, AACE, Juni 2005, S. 3453-3460.

ResourceCenter
A Digital Learning Object Repository with an Integrated Authoring Tool Set

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Abstract: The ResourceCenter, which we describe in this paper, is a web-based digital repository for learning objects with an integrated tool set for authoring of SCORM-compliant courses. We developed this integrated system and the scientific concepts to promote the use of learning object repositories and the reuse of learning objects. With the ResourceCenter and its components - Metadata-Wizard, Course-Structure-Editor, and Section-Content-Editor - we make contributions to different aspects in the domain of learning objects, such as the semiautomatic generation of metadata, modularization of learning objects and authoring by aggregation.

Introduction

Reusability of learning objects and powerful authoring tools have been propagated as an instrument to reduce the high costs, in time and money, for production of e-learning content in recent years. Much of the research in e-learning has focused on the notion of reusable learning objects, on metadata, and digital repositories for learning objects. The infrastructure exists, but reuse of learning objects remains a theoretical approach and does not happen in practice. Authors of learning objects do not feel competent to describe learning objects with metadata and to provide them with repositories. The process is too cumbersome, compared to the personal benefits, on the one hand. On the other hand, it has meanwhile become widely accepted, that the same learning object cannot be used in significantly different contexts. To reuse learning objects, users must be able to repurpose them for their learning context, which means that content is adapted for features such as layout, language, terminology, or previous knowledge. But even in homogenous groups of authors, working on a specific domain, where repurposing is not necessary, reuse does not occur. We observed this in different projects, especially in the project k-MED (k-MED Consortium 2004), with many academic teachers and scientists from different medical faculties. Another observation was that authors are swamped with numerous functions of commercial authoring tools for building SCORM 1.2 (Advanced Distributed Learning Initiative 2001) compliant web-based training, like HTML-editors or more intelligent e-learning course editors.

These observations served as the starting point for building the ResourceCenter. At the core, the ResourceCenter is a digital repository for learning objects described by IMS Learning Resource Metadata, a web-based authoring tool set, consisting of a metadata editor, a metadata wizard for semiautomatic generation of metadata, an editor for structuring courses, an editor for text-based learning objects with integrated multimedia resources, and an export generator for SCORM-compliant courses.

In the following section we will describe the state of the art in reusability and authoring of learning objects, and the existing challenges observed generally and in our project. It follows a review of the ResourceCenter, its functionality, the technologies used, the architecture, and its contributions to solving the problems. Technical and application specific experiences, gained in the use and operation of the ResourceCenter within the project k-MED,

are presented afterwards. The paper ends with a conclusion and an outlook regarding intended extensions.

Reuse and Authoring of Learning Objects

Reuse of Learning Objects - Digital Repositories, Metadata, Modularization

The technological base requirement, necessary to allow the reuse of learning objects, is a digital repository for learning objects (LOs), called a Learning Object Repository (LOR) in general. The LOR stores learning objects from different users described by metadata, which support the indexing of, and the search for objects. The functionality of such LORs that manage content is beyond the scope of standard database systems, they allow for example, authorization, provide different searching capabilities, and advanced configuration management. Many efforts have been made recently to implement LORs (Neven & Duval 2002), and especially to define metadata models and standards. Much effort has been put into LO-research by the ARIADNE Foundation (ARIADNE Foundation 2004). Ariadne provides a variety of tools. The core tools, especially the Knowledge-Pool-System, a LOR, allow indexing, storage, and search of various Learning Objects (Duval et. al. 2001). Examples of other LORs are Multimedia Educational Resource for Learning and Online Teaching (MERLOT) (Merlot 2004), the SMETE Digital Library (SMETE 2004), Campus of Alberta Repository of Educational Objects (CAREO) (Careo 2004) and DSpace (DSpace Federation 2004), which is used, e.g. by the MIT Open Content Initiative and is also not restricted to learning objects. A complex overview is given in (Neven & Duval 2002). With respect to LORs, the IMS Global Learning Consortium Working Group Digital Repository Interoperability (DRI) (IMS Global Learning Consortium 2004) specifies a reference model for digital repositories (IMS Global Learning Consortium 2003), not specialized for learning objects.

In the metadata area, the most significant standard is the IEEE Learning Objects Metadata Standard (LOM) (IEEE Learning Technology Standards Committee 2002), finalized by the IEEE LTSC in 2002. LOM defines 58 data elements structured in 9 categories, each of which covers specific aspects, such as technical or educational characteristics to describe learning objects. LOM is almost identical to IMS Learning Resource Meta-data Information Model 1.2.1. More general, and not specialized for learning objects, is the Dublin Core (DC) metadata element set that defines 15 metadata elements.

Despite the existence of LORs and metadata editors, authors do not feel competent to place their learning objects in repositories and to describe them by metadata, unless they are forced to do so or if they have a commercial interest. The extra amount of effort to add metadata to their LO is too big and no culture of reuse exists. Reuse of learning objects in different contexts is easier if learning objects are small in granularity than if they are large. But, authors think in lager structures, like lessons or course chapters, typically, instead of small modules. They are not very familiar with authoring small learning objects. These common observations correspond to our experience in different projects. So authors place, if at all, only larger learning objects in LORs and not smaller ones.

To sum up, different challenges exist, and they are the subject of our research:

- acquisition of metadata has to be simplified or replaced by semiautomatic generation,
- big learning objects have to be split into small objects, which are stored in LORs,
- authors have to be forced to use LORs or should use LORs in a transparent manner.

These aspects are a subset of those in (Duval & Hodgins 2003).

Authoring of Learning Objects

Various formats of learning objects exist. They range from presentations in ppt-format and text documents in pdf-format to e-lectures with integrated videos and annotated presentation slides, or complex courses. Some of these are stored in content packages, as specified in the SCORM specification. The range of e-learning authorware and editors is as broad as the types of formats which are involved in e-learning. An accepted classification for authoring tools does not exist. For production of SCORM-compliant learning objects, we can distinguish between HTML editors with learning specific extensions, e.g. Macromedia Dreamweaver with Coursebuilder, and specialized authoring tools for web-based trainings, which can be distinguished, again into page-based tools, e.g. Click2Learn Toolbook

Instructor, flow chart based tools, e.g. Macromedia Authorware, and timing diagram based, e.g. Macromedia Director or Adobe After Effects. Format converters, which convert a Microsoft Office document in a SCORM-compliant LOs also exist, but they are only of limited use.

All these tools offer an extensive set of functions which, in many cases, demand too much of the authors. Authors cannot concentrate on the textual structure and the textual content; they have to worry about formatting and layout, about media specific tasks and also about didactical structure. This complexity is reduced by using templates, and defining the format and/or the didactical structure. The drawback of using such templates is that authors can be limited with respect to the content. We experienced this, when we offered a set of fixed Dreamweaver templates to the authors in our project. Another disadvantage is that authors have the opportunity to define the formatting themselves, which results in inhomogeneous layouts of the resulting learning objects. In addition, these tools use different proprietary formats and have a document form which does not support modularization and reuse.

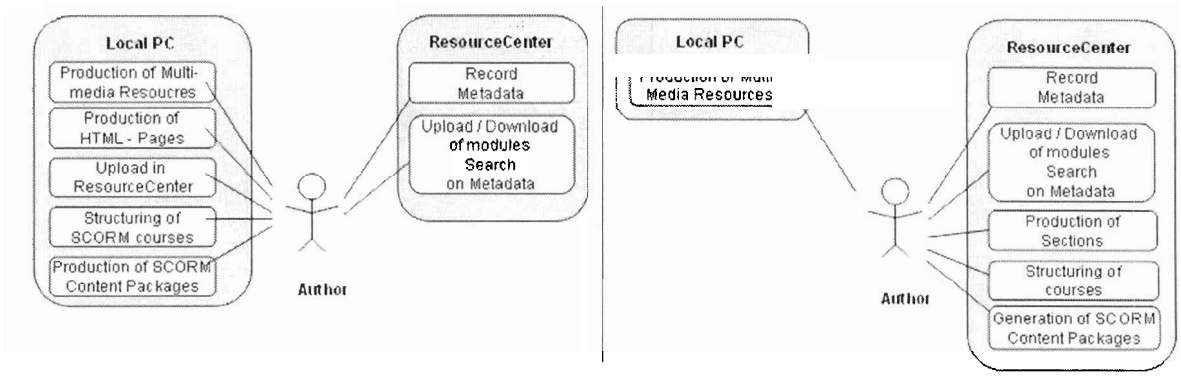
XML editors are, in addition, presently proposed as authoring tools for learning objects. The representation of learning objects in XML allows the creation of structured content, the description of its semantic meaning and the manipulation of the content in various ways to achieve different educational outputs. These are many advantages, but, existing XML-editors are not user-friendly. Authors should have XML skills to use them.

Another major problem is the reauthoring or repurposing of existing learning objects for use in different contexts. Authoring tools do not support repurposing in different dimensions, like layout, didactics, or language and they do not support modularization and aggregation of LOs. Content is not designed to be repurposed, source documents are not available, content and formatting information is not separated.

Two great aspects, among many others, remaining in the area of authoring should be pointed out here: Namely, the provision of simple authoring tools, especially to generate XML-based learning objects, and the definition of a learning object content model and data structures which will allow repurposing.

The ResourceCenter

The ResourceCenter is a digital repository for LOs of any type and granularity described by IMS Learning Resource Metadata and a set of tools supporting the author's work of building SCORM-compliant courses. The major goal was to integrate authoring tools in a digital repository, managing the authored content in a layout-independent, XML-based data model. This is our approach to deal with the problems and challenges described in the sections above. Figure 1 shows the use cases without the integration of authoring functionalities in the Repository and the use cases using the ResourceCenter.



a) Use Cases without integration of authoring in ResourceCenter b) Use Cases with integration of authoring in ResourceCenter

Figure 1: Use Cases for an author

Besides this, a major goal was to implement simple workflows that support authors when creating and structuring a course, and when editing section content and adding media resources to sections with nearly transparent creation of metadata. Every creation or upload process, even if it is a course, section, table, or media resource, creates a metadata record and forces the author to describe the LO with a minimal set of metadata information to create a

SCORM-compliant metadata record with help from the Metadata Wizard. The Metadata Wizard gathers information from the user profile, the resources themselves, and from the context in the workflow. Finally, the ResourceCenter offers a function which exports a course to a SCORM-compliant file.

Functionalities of the ResourceCenter

By integrating authoring tools in a repository for learning objects, the main functionalities of the ResourceCenter are:

- managing of resources - upload, download, searching, description by metadata
- authoring of resources - course structuring, section authoring
- administration of resources, user accounts, and profiles

In the following, we describe the authoring tools, the Course-Structure Editor, and the Section-Content Editor in depth.

The Course-Structure editor allows the author to organize sections in a hierarchical course structure. Therefore they create empty sections or queries for sections in the repository and add them to their structure. Functions which manipulate the course structure, directly accessible with the editors toolbar, are (Fig. 2) "Add empty section", "Insert section from the repository", "Move section up or down in the structure", "Increase or decrease the indent of a section (implies chapters)", "Cut and paste sections", "Remove sections from the structure"

Finally, the export function can be found on the toolbar of the editor. It triggers the SCORM export, which creates a SCORM-compliant content package. The author can save the course package to the local hard disk and import it to any SCORM-compliant LMS.

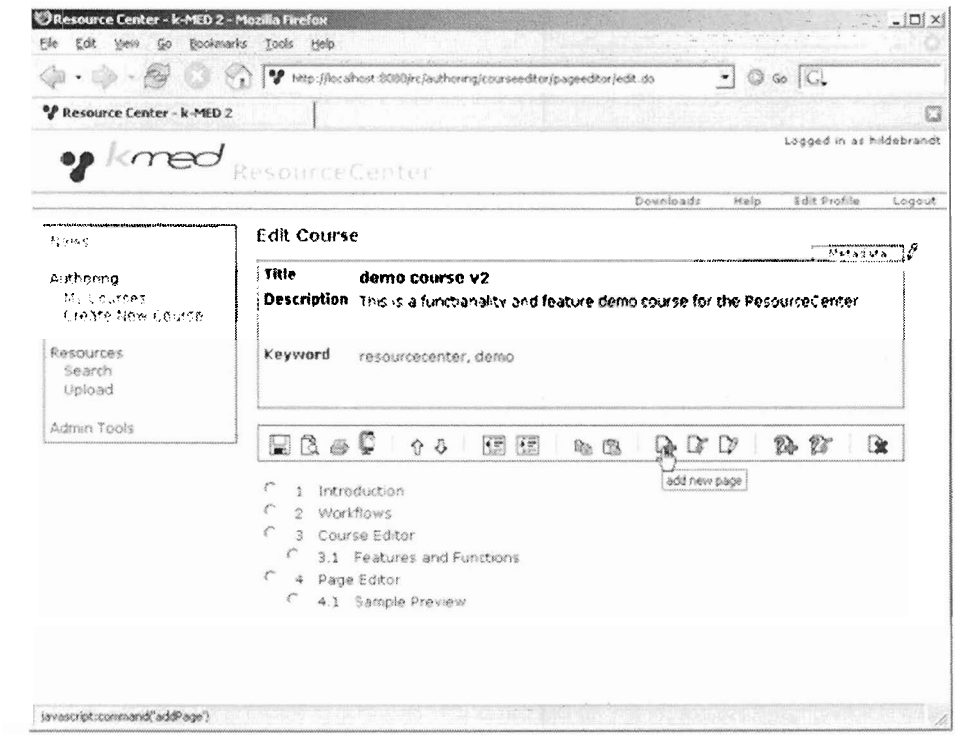


Figure 2: Screenshot of Course Structure Editor

With the aid of the Section-Content editor, the author can edit and structure text and add media resources of any type in so-called blocks. These blocks are units of text and media resources which belong together. This ensures layout-independent authoring to permit repurposing. A section can consist of any number of blocks. The author can add a page break between two blocks, to split a section into consecutively numbered HTML pages with the same title.

Therefore they can use a preview function, which allows the author, at any time, to receive a preview and to browse through the course structure and authored sections. The SCORM course player and the preview function will render all blocks between two page breaks to a single HTML page.
Figure 3 shows the Section-Content editor with one block containing text and an associated media resource. The preview and the export renders the resulting HTML pages with a given layout. This layout can be easily adapted to fulfill other requirements. It consists of an XML transformation and a corresponding cascading style sheet.

In the same way that the course structure editor forces the authors to describe their courses with metadata, the section content editor acquires title, description and keywords from the author. The author's profile and the workflow state are used to fill a complete metadata record, to make the section accessible in the repository. By uploading a media resource to a block, the upload and insert workflow ensures, with the aid of the metadata wizard, a complete metadata record.

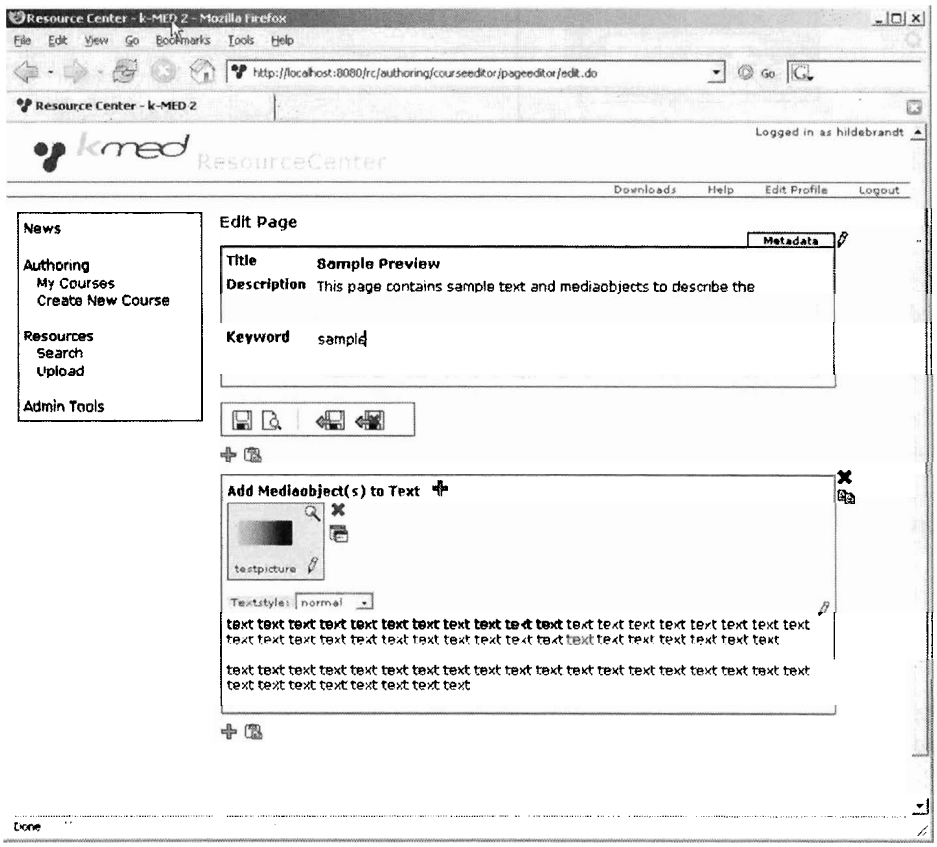


Figure 3: Screenshot of Section Content Editor

Architecture of the ResourceCenter

The ResourceCenter is a Java web application based on the Apache Struts Framework (Apache Software Foundation 2004a). Struts encourages application architecture based on a variation of the Model View Controller (MVC) design paradigm. An Apache Tomcat serves as the servlet container for the ResourceCenter. Beside the ResourceCenter, two other web applications run on Tomcat. These are the XML Database Xindice (Apache Software Foundation 2004b), which holds and manages the Metadata Records, and the context-sensitive Help System. The repository uses the local file system for binary and character resources. User accounts and profiles are stored in the SQL Database. Figure 4 shows the overview of the architecture of the ResourceCenter. The client simply requires up-to-date web browsers.

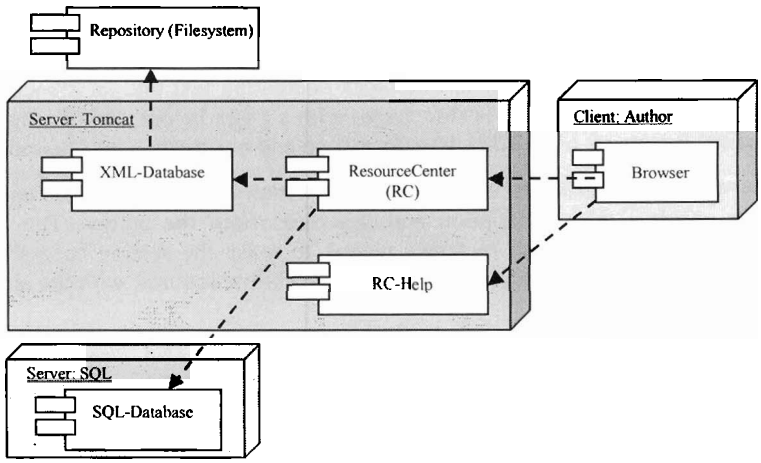


Figure 4: Architecture of ResourceCenter

Benefits

The ResourceCenter acquires transparent metadata during creation of courses, sections, and tables, and during upload of media resources from the local hard disk to a block. Because of the layout independent sections, authors are able to split sections already in the repository to repurpose it for their personal needs. By integrating authoring workflows in a digital repository for LOs, authors are forced to use the LOR.

In addition, the ResourceCenter comes with an easy to use user interface, and implements authoring workflows, so that authors can focus simply on writing text and linking corresponding media resources.

In summary, the ResourceCenter is a full featured authoring environment that makes many contributions to the different challenges described before.

Experiences in the Utilization of the ResourceCenter

The core functionality of the ResourceCenter: upload of learning objects described by metadata, searching, and download, were implemented in 2003 and have been used in the project k-MED since September 2003. The experiences have been the same as in many projects, as described in the last section. Authors (around 12 experts in medicine education) have been not able to use the repository. They were only interested in building courses with local tools and importing them into the learning management system. In one year, only 200 learning objects have been uploaded to the ResourceCenter, and most of these learning objects were complex courses mostly, as shown in Table 1.

In October 2004, we provided the new ResourceCenter with the extended functionality, described above, and a personal training for authors. In the following two months more than 2000 different resources of different granularity have been uploaded.

Kind of Learning Object	September '03 till September '04	October '04 till December '04
SCORM – course	165	95
Sections of a course	35	928
Figures & Animations	0	840

Table 1: Number of LOs stored in ResourceCenter

Remarkable is, in addition, that learning objects are reused more and more. Presently this observation is based upon individual statements of authors. Measurements have to be made in the future. Authors feel very comfortable with the continuous workflow support of the ResourceCenter and the possibility of creating the learning objects using the authoring tool as part of the ResourceCenter, instead of local complex tools. They are relieved of the burden of formatting the learning objects or adapting the content to a set of given templates.

Apart from these application-specific experiences, we also gained technological insights. Querying for learning resources in the ResourceCenter does not scale with the number of learning resources, as the results of our measurements in figure 6 shows. In measurements 1 and 2, we measured the duration for querying and displaying of the hits with full text search for a word in the title, description, and keyword of the metadata records. In the case of measurement 1, there were no hits, and in the case of measurement 2, there were 100 hits. For measurements 3 and 4, we indexed all data fields which were relevant for the search, in order to accelerate the search. Since Xindice does not support full text search within the index, we extend the query of measurement 1 and 2, in order to increase the performance by using the index. Therefore, we extended the query of the measurements 3 and 4 by an AND-operation for a certain learning resource type. Measurements 3 and 4 had no hits and 100 hits, respectively.

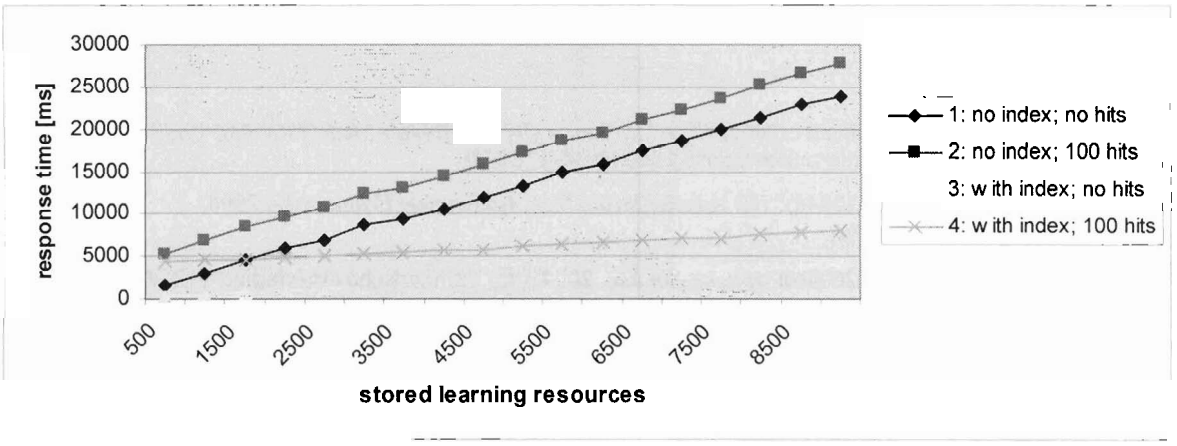


Figure 6: Measurements of response times

The measurements show that there are two time-critical parameters when performing queries for learning resources. Measurements 1 and 3 provide information about the duration of the query, depending on the number of metadata records stored in the Xindice database. The comparison shows that response time of the database can be accelerated by using the index up to factor 5. However, since the AND-operation of a word with a certain learning resource type is not frequently given in our scenario, we only rarely encounter this advantage. Measurements 2 and 4 show, compared with the measurements 1 and 3, that the processing of the query results also causes high costs. Here the major part of the costs is caused by the ResourceCenter when displaying the query results. From these results we draw the conclusion that we should not use XML to store metadata which is relevant to query learning resources and to display the query results. Thereby we avoid expensive operations on DOM. In order to reduce the query time of the database, we will change from Xindice to an SQL database which supports full-text queries on the index.

In addition to the project k-MED we use the ResourceCenter in a completely different domain, in linguistics. Thereby, we have the same positive experience: authors feel comfortable with the authoring tools such as those for k-MED.

Conclusion and Outlook

With the ResourceCenter, we have built a digital repository for learning objects with an integrated authoring tool. It makes a very useful contribution to encourage acceptance of the idea of reuse of learning objects. Especially Authoring by Aggregation, as defined in (Duval & Hodgins 2003), is supported. So far we only have provided the

evidence for a homogenous project group of authors working in a specific domain, where reusability is easier to establish than in inhomogeneous groups. But in addition, due to the format-independent representation of text-based contents using XML in the ResourceCenter, the technological basics for repurposing of learning objects for use in different contexts are established. The adaptation of different layouts can be simply made by the implementation of different XSL transformations.

Further steps and extensions of functionality are a more comprehensive workflow support, e.g., using the status information which is part of the metadata, a user specific virtual working environment, with information like "my courses" or "my resources" or ranking of search results. Work in progress is the integration of an ontology-based knowledge network for two purposes - the description of learning resources by selection of a concept of the ontology first and access to learning resources by browsing the knowledge network, instead of searching in a second step. Also, work in progress is the replacement of the XML-database by a relational database to achieve better scalability. Enhancements are necessary to support the upload and integration of different media types beyond jpeg-pictures and Flash-animations, first of all, and in the implementation of a different XSL-transformation to comply with the varied layout wishes.

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