

Digital libraries in knowledge management: an e-learning case study

M. Fuchs, C. Muscogiuri, C. Niederée, M. Hemmje

Fraunhofer IPSI, 64293 Darmstadt, Germany
e-mail: {fuchs, musco, niederee, hemmje}@ipsi.fhg.de

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Abstract. Knowledge and libraries – this conceptual symbiosis is as old as the idea of libraries itself: libraries collect artifacts of explicated knowledge and make them available for building up new knowledge in all areas of everyday life. Learning and qualification management support are further essential links in the knowledge supply chain, which starts at the expert knowledge of an author and ends at the targeted enhancement of another person's individual knowledge. Digital libraries and e-learning systems are thus important enabling technologies for the knowledge supply chain in the digital age.

The e-Qualification project presented in this paper combines digital library, e-learning, and authoring support into an adaptable qualification management framework that provides integrated support and mediation for the various stakeholders involved in the qualification management process.

Keywords: Metadesign – System authoring – Knowledge management – Qualification management – e-Learning

1 Introduction

Courses, examinations, exercises, skill profiles, course profiles, etc. are the manifold information ingredients that have to be managed and made accessible in an e-learning system. A digital library provides powerful and efficient functionalities for content management (acquisition, storage, indexing, access, and maintenance), manifold metadata for content enrichment, and structuring, as well as services for effective content search, access, annotation, filtering, and dissemination. The content and services a digital library offers are determined by acquisition (collection development), organization, and access policies tailored to the community the digital library is intended to serve [9].

In a qualification management (QM) framework, library functionalities have to support specific content-to-community mediation-facilitating identification and access of relevant learning-related material. Due to the characteristics of the learning content and the related QM processes, additional mediation that is tailored to the learning context is necessary. This mediation covers content structuring and content consumption in addition to content access.

This paper discusses a QM framework developed in the e-Qualification project [3], which builds upon a QM digital library as a core component, adding mediation services like shared workspace and qualification consulting for improved QM support. The flexibility required by the variety of dynamically changing QM scenarios is achieved by offering authoring support on three levels:

Content authoring support for the flexible structuring of course building blocks into courses, fostering personalization and reuse of learning content;

Library and mediation authoring support for library structuring tasks, for the integration of courses into the overall library structure, and for content enrichment. In addition, the framework supports authoring of mediation processes like the setting up of learning groups and the definition of qualification consulting rules.

System authoring support for setting up e-learning systems in the presented framework and for customizing them according to the requirements of the underlying QM process and the stakeholders involved.

The rest of the paper is organized as follows. Section 2 describes the mediator role of a digital library and the special requirements of considering learning material as library content. In Sect. 3 the different forms of mediation in the QM process are discussed. The framework for integrated flexible QM support designed and implemented in the e-Qualification project is discussed in Sect. 4. We conclude the paper by summarizing the e-Qualification

project experience in three lessons learned from exploiting digital library functionality in an e-learning context as an example of a knowledge management application.

2 A qualification management digital library

Digital libraries aim at supporting the information and knowledge needs of a user community and acts as a mediator between the available content and the user community. They provide contributions in four areas to fulfill this mediation role (see Fig. 1 and [13]):

Content preselection: The library selects high-quality content that is (potentially) relevant for the intended user community.

Content structuring: The library structures the content according to the predominant domain understanding of the user community.

Content enrichment: Domain experts and community members enrich content objects with descriptive and value-adding metadata.

Library services: Services for content retrieval, access, annotation, etc. support the identification of relevant material and facilitate content access.

A key advantage of a digital library when compared with paper libraries is that it is open to a wider variety of new content types [8]. However, new content types may require adapted content mediation support like additional metadata, special structuring, and dedicated service as well as new methods for the preselection of high-quality content objects. This also applies when we consider courses and other learning-related material as content of a digital library:

- Unlike many types of content like papers, technical reports, etc., which are still often printed out for consumption, Web-based training (WBT) content is explicitly intended for online consumption.

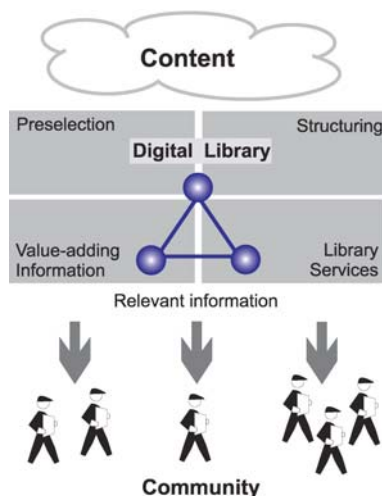


Fig. 1. Digital libraries as content-to-community mediators

- Course content is very dynamic in its nature considering that content has to be frequently extended, re-organized, and adapted by domain experts like course authors and trainers according to a changing context of usage as well as specific learning goals and processes.
- Concise QM requires additional superimposed information like course learning goals and course preconditions. Such metadata enable individual, skill-aware qualification planning, and consulting.

3 Extended content-to-community mediation

Digital libraries support teaching and learning not only by playing a role in sharing, preserving, and organizing content but also by bringing together people with different perspectives and ideas. Moreover, the digital medium lowers the boundaries between content providers and content consumers [10].

In the QM digital library the user community is not restricted to students but also includes tutors and other mediator roles, all of whom contribute to the mediation between qualification needs and available content and profit from integrating support for the different roles in one QM system.

3.1 The e-Qualification project

The e-Qualification project [3], a current project funded by the BMBF,¹ aims to provide a framework for the production and application of innovative teaching/learning software in supporting the entire QM knowledge supply chain including

- provision and management of focused, high-quality training material,
- qualification goal planning,
- skill-aware selection of learning content, and
- effective step-by-step learning support.

The expertise of several research institutes is bundled in an interdisciplinary project consortium in order to handle the manifold requirements imposed by these tasks. The project has already resulted in an e-learning portal framework, a running prototype system based on this framework, and a systematic collection of methods and templates for effective course production targeting various learning situations.

3.2 Mediator roles in qualification management

Supporting the entire QM knowledge supply chain is a challenging task that involves several actors in different roles. Portal provider, domain manager, qualification

¹ Bundesministerium für Bildung und Forschung – German Federal Ministry of Education and Research

consultant, and tutor all represent roles that contribute to the mediation between the qualification needs of learners and the available WBT content ([6]):

- QM portal providers act as mediators between the produced WBTs and the learner community as potential clients of the WBT product. They make the WBTs available, control access, and offer community services.
- QM domain managers support the portal providers in their mediation task by organizing available WBTs, required learner skills, and qualification goals into the qualification knowledge domain.
- Qualification consultants support specific learners in course selection and qualification planning, mediating between the available content, qualification goals, and prerequisites of the learners.
- Tutors mediate between a specific WBT course and an associated group of learners (virtual classroom). They support learners in the knowledge acquisition process.

A finer-grained QM support can be achieved by a refinement of roles according to subtasks, individual preferences, and working styles considering, for example, different types of learners.

3.3 Integration synergies

Various task-specific system services are necessary to support the different roles in the QM process. The e-Qualification project advocates the idea of an integrated but open and extensible QM framework that incorporates system support for the different roles, fostering the following integration synergies [6]:

- The coexistence of all roles in one system context introduces new opportunities for interrole communication.
- On the semantic level, the sharing of a QM core model and of a common knowledge infrastructure contributes to the creation of a common domain view for all involved partners.
- On the service level, the shared use of a service infrastructure lowers the boundaries between roles [5, 14].
- If all contributing WBT authors rely on the authoring support provided by the integrated system, this contributes to the homogeneity and consistency of the produced course material.

The QM process, the roles involved in the process, and the underlying knowledge supply chain vary considerably in different QM contexts like private universities, schools, public universities, etc. Furthermore, QM processes and mediation policies are subject to change. Therefore, the e-Qualification framework systematically supports the stakeholders involved in the QM process in contributing, depending on their roles, to the refinement and evolution of mediation policies and processes.

4 Flexible qualification management support

The e-Qualification framework achieves the flexibility needed in the variety of dynamically changing QM scenarios by offering authoring support on three levels:

Content authoring support enables the flexible composition of courses from course building blocks, fostering the reuse and personalization of learning content. Once uploaded, course building blocks are stored in a qualification management digital library, the content DL (see Fig. 2), and can be flexibly reused to build up courses for different types of learners and specific learning goals. The e-Qualification content authoring tools support content upload, course composition, and the cooperative process of course creation.

Library and mediation authoring support deals with building up knowledge structures for the library, organizing the content into these knowledge structures, and enriching learning content with general and qualification-related metadata, improving effective content retrieval and selection. Mediation authoring enables the customization of the mediation process between content and learners (for example, by defining qualification consulting rules).

System authoring support consists of Web application authoring tools that empower special users like portal providers to take an active part in QM system customization and evolution, e.g., supporting new roles. This approach is based on the idea of user empowerment [11], that is, its aim is to enable (empower) users not only to use the system but also to adapt it to changing requirements. It must be noted here that we do not expect users to develop an entire QM solution from scratch on their own. The focus is on small incremental changes and adaptations in an operational system.

The system authoring tools create and manage Web application objects from different domains and on different levels of granularity like hypertext navigation maps, business process steps, Web pages, form fields, entities from the application domain, user tasks, etc. that have to be stored, navigated, and

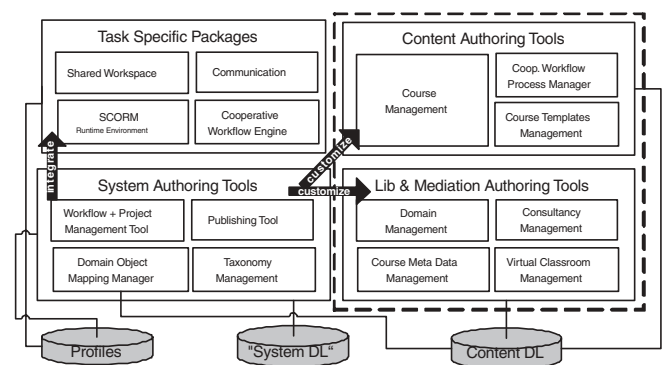


Fig. 2. Architecture of the e-qualification framework

accessed in the authoring process. In this situation, some of the structuring facilities of a digital library can be exploited.² A prominent example is the taxonomy management component of our system [12], which is employed for content structuring, navigation, and access as well as for organizing and accessing Web application objects.

Flexible support for the aforementioned authoring processes is achieved in the e-Qualification framework by supporting three classes of components:

- Modular, task-specific packages;
- Content, library, and mediation authoring tools;
- Generic authoring tools.

A detailed description of these three component classes is given below.

Modular, task-specific packages: Components of this class provide predefined application functionalities and form the basic building blocks for setting up a QM system. In the e-Qualification framework, task-specific packages include:

- A groupware infrastructure package providing shared workspaces, address book, and calendar [2, 7];
- Communication infrastructure packages including context-aware audio/video conference support and a chat system for learners and tutors;
- A cooperative workflow infrastructure package powered by a cooperative workflow engine [15];
- A runtime environment supporting tracking of users and individual learning progress, compliant with the standard WBT metadata model specification (SCORM specification).³

Content, library, and mediation authoring tools: These tools provide functionalities for the definition and management of typical content objects and mediation processes in the QM domain. This tool suite includes:

- Domain Manager, building upon the Taxonomy Manager, to define multiple classifications of arbitrary resources in the QM domain and to support the dynamic evolution of the QM domain. It also offers access to course material by browsing/navigation of the QM domain network;
- Qualification Consultancy Manager to build up questionnaires and define rules for the evaluation of the questionnaires;
- Cooperative workflow process managing tool to plan and execute a cooperative course authoring process;
- Course Manager to upload course units, to structure the course units within a course providing reusability of course units, to upload or enter metadata, and to define the control flow for courses fruition (e.g., by defining prerequisites);

- Course Template Library to support authors and provide templates for course navigation, content, tests, and manuals;
- Virtual Classroom management tool to allow tutors to set up, drive, and control the activities of course participants.

Generic authoring tools: These tools provide functionalities for QM system setup, customization, and evolution. This tool suite contains the following components:

- Workflow + Project Management for the structuring and management of the Web application development project;
- The Domain Object Mapping Manager is used to define semantically enriched mappings between the QM domain model and the underlying application data, e.g., user profiles, metadata, courses. These mappings defined during the system authoring process are dynamically translated into flexible bindings to actual instance data at runtime;
- Publishing tools enable the definition of Web-based user interfaces and their coupling with domain model and application logic activities from the task-specific packages;
- The Taxonomy Manager is used in the system authoring process to classify Web application objects and to facilitate cooperation among authoring tools ([12]).

The three classes of components are combined in the e-Qualification framework architecture (Fig. 2) in order to support evolutionary content and system design for QM systems. The authoring tools are used to customize system functionalities, content structure, mediation policies, etc. to the specific and changing requirements of a QM context.

5 Lessons learned

From the experiences in the e-Qualification project and other related projects building upon the presented framework the following lessons have been learned for the exploitation of digital library functionality in a knowledge management context:

- Digital libraries play a crucial role as “standalone” systems in mediating between the information requirements of a user community and the available content. In addition, they may also play an important role as integral parts of larger systems, supporting content and knowledge management processes.
- New types of library content may not only impose additional requirements on content preselection, structuring, enrichment, and access services supported by the library but may also profit from integrated support for the other phases of the content life cycle like content provision and content consumption.
- Content usage and production patterns as well as mediation policies and processes depend on the specific

² That is why we use the term system DL in Fig. 2.

³ SCORM = Shareable Content Object Reference Model [1]

e-learning context and dynamically evolve over time due to changes in the underlying QM process. Flexible authoring support as provided in our framework is a powerful approach to involve different stakeholders into the required system adaptation process. Library and mediation support, on the one hand, and system authoring support, on the other hand, facilitate adaptation to different communities, QM contexts, and changes in the QM process and foster the implementation of QM systems in which all involved roles can contribute to the evolution of the underlying digital library's content and services.

The idea that a wide range of evolutionary changes in content, content structuring, mediation, business processes, and system functionality can be supported in the system itself by empowering the users to participate in system setup, customization, and evolution bringing in their domain expertise is not limited to the e-learning domain but is also applicable to other problem domains. Currently we are applying the evolutionary Web application framework developed in the e-Qualification project to evaluate the approach in a more business-oriented domain. The EU-funded FairsNet project [4] aims at implementing a Web-based IT system to flexibly support trade fair organizers in managing their entire business cycle of planning, organizing, and running exhibitions and related online events. New task-specific authoring tools have to be introduced into the framework for their purpose. This includes a flexible and effective integration of specific content management, cooperation mechanisms, retrieval support, and data analysis functionalities like fair customer registration, booking of stands and services, as well as fair catalog management.

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