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Distributed Repositories for Educational Content

Part 1: Information Management for Educational Content

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Abstract

As education providers increasingly integrate digital learning media into their education processes, the need for the systematic management of learning materials and learning arrangements becomes clearer. Digital repositories, often called Learning Object Repositories (LOR), promise to provide an answer to this challenge. This article is composed of two parts. In this part, we derive technological and pedagogical requirements for LORs from a concretization of information quality criteria for e-learning technology. We review the evolution of learning object repositories and discuss their core features in the context of pedagogical requirements, information quality demands, and e-learning technology standards. We conclude with an outlook in Part 2, which presents concrete technical solutions, in particular networked repository architectures.

Keywords: Educational content, content sharing, information management, information quality, learning object repository

1 Information Management

E-learning uses the functions of modern information and communication technology for teaching and learning. When e-learning is being introduced or new technologies are being developed, short-term goals are important to ensure dissemination and acceptance among learners, teachers, and decision-makers. Later, in the consolidation phase, increased use is associated with the desire for systematic and structured management of digital resources. This can be conceived as information management for educational content with the ultimate goal being information quality (KRCMAR 2005, p. 111).

1.1 Information Quality

On the broadest level, information quality refers to the fitness for use of information maintained in an information system. Information quality has several quality criteria that impose the following requirements on developers of technical solutions:

- ensure consistency,
- avoid redundancy,
- control access, and
- strive for relevance for the recipients of information.

Information quality in e-learning

In this article we restrict our discussion to the use of information and communication technologies in education – that is, in e-learning. Further, we consider primarily digital learning content, such as teaching texts, interactive educational software, animations, simulations, exercises and tests. In this context, information quality criteria can be easily explained for technical and organizational solutions and can be put into context with pedagogical goals as follows:

- **Consistency.** Information imparted in educational processes must be logically coherent and free from contradictions. When digital technologies are used, ensuring data consistency appears straightforward: digital data can be transferred easily between different systems and equipment. However, in media production (including e-learning) data is often copied before it is exposed to the intended target groups. For example, if additions and corrections need to be made to educational software that is disseminated to learners in the form of web-based training modules via virtual learning environments, the modules affected by these changes have to be replaced in a whole range of ongoing courses. If content is relevant for examinations, the learners want to use the versions that they were taught with, even if newer versions are available. Consistency also concerns multimodal presentations, such as animations and spoken explanations of what is happening in the animation. Finally, even in e-learning environments, different forms of presentation such as online and print material must be kept consistent.
- **Avoiding redundancy** will reduce management efforts and avoid multiple expenditures. If data is copied, the expenditure of keeping information up to date, complete, and consistent increases considerably. In the ideal case, information recipients always obtain learning content directly from a single source, regardless of the access path and regardless of the presentation device used. This source is always up to date and provides access to earlier versions if available and necessary. This ideal appears feasible as more people have access to the Internet and as mobile devices like netbooks, smartphones, and e-book readers increase in popularity. That way, learners can not only access information from everywhere and at all times, they can also use digital learning programs that are offered from one single, original source.

- **Controlling access** to information is an important condition when learning content is used in a commercial context or if access to education courses is constrained (see also Section 1.2, Open Educational Resources). To protect learning materials and the participants' personal data, virtual learning environments typically organize educational offerings such as seminars or training sessions in classes, courses, or other types of groups and assign virtual study rooms and cooperation tools to such learner groups. Traditionally, educators copied digital learning material into the study rooms. With today's technology, they could use links to the original sources, instead, and associate appropriate access rights with such links. A teacher would then be able to follow the link to a resource and modify it, while a student would just be able to reference the resource. One reason for the practice of uploading copies of learning material into virtual study rooms is most likely the practical handling of copyright issues. Material that is available only within the scope of an enclosed (virtual) classroom often does not infringe copyrights. If material is managed in a widely accessible repository, however, intellectual property rights must be handled properly (that is, ownership and usage rights must be clearly specified).
- Restricting access to a learning resource is closely related to the **relevance** of this resource **for individual recipients**. In the context of e-learning, this concept also refers to the actual situation of the individual learner. Unrestricted access is of little use if the learner is drowning in a flood of information. Matching the information sought to the information needed to complete the current tasks in the learning and work process is required to ensure the quality of the information retrieved. It is well known that information becomes knowledge only in context. This raises questions about the personalization of learning content and about the possibilities for adapting and tying the content to the situation. Hence, the goal of a pedagogically practical way of dealing with digital learning content cannot consist in just making it accessible to a large crowd at the same time. Rather it is necessary to provide content in relation to the learners' current information needs and prior knowledge to allow them to develop knowledge and skills gradually.

1.2 Information Management with Learning Object Repositories

Digital repositories for managing educational resources, also called *Learning Object Repositories* (LORs), provide storage capacity and technical functionality that helps to realize information quality principles in practice. They serve to manage educational content of varying type and granularity systematically and independently of a particular application or virtual learning environment. A LOR can be accessed via communication networks and uniform access methods. This allows repository users to search, browse, upload, use or download digital learning content without prior knowledge of the internal organization of the repository (IMS 2003).

Digital content repositories support both opportunistic and planned reuse. *Opportunistic reuse* occurs when a course author realizes that there exist learning objects in the web or in open repositories that she can reuse. This can be an animation, a simulation, a definition with explanations and examples, a case study or another unit of learning supporting a particular learning objective of the course und development.

Planned reuse requires a community of authors who design learning objects with the intention to share them with others and reuse shared objects in future courses. This is where the idea of “learning objects“ becomes noticeable (LOCKYER ET AL. 2008). A digital content repository is a key enabler of planned reuse.

These ideas are carried forward in the *open education* and *open educational resources* (OER) movements, which promote the idea of free digital learning material based on the principles of public interest and mutuality (GESER 2007). They advocate that digital learning material financed through public funding (particularly at universities and schools) should be freely available to the general public. However, the strength of OER is also its weakness: the provision of masses of educational content is not sufficient to ensure a successful learning process. This motivates two requirements: an educational selection process is needed to handle the abundance of information, and open educational resources must be related to good practices in teaching and learning. Section 4 presents a learning object repository (LOR) addressing both requirements.

The possibility of independently structuring and organizing learning processes (*self-directed learning*) is often described as the key added value of learning with digital media (VRIES, BRALL & LUKOSCH 2009). Learning-on-Demand or Just-in-Time-Learning is almost inconceivable without LORs.

Commercial providers of digital learning content, such as publishers of educational material and other content providers, need distribution channels to market their products. Web-based trading platforms (market places) for digital learning content have been developed to address this need. Examples for such market places include www.copendia.de and www.webkolleg.nrw.de in Germany and coggno.com in the United States. Such market places allow media producers to offer their products, which range from educational software to entire media-supported courses and degree programs, to interested parties (BENTLAGE; GLOTZ & HAMM 2001). However, existing trading platforms are aimed mainly at marketing, sales and, purchase. Traditional sales channels are still used for delivery: Either the content provider transfers the media product to the licensee (the education provider), who then provides it to end users via a virtual learning environment, or the media product remains with the content providers and end users access the content directly from within the virtual learning environment. This requires that user data be sent to the content provider. Integration of content, available from the content provider, into the digital learning environment of the education provider is currently still an exception. It appears that there is a need to network repositories for learning content.

To ensure that the concept of *lifelong learning* does not merely remain a hollow phrase, education facilities and education providers are discovering their own graduates as target groups (cf. SCHULMEISTER 2007). The intention is to offer needs-oriented *further education* and advanced training courses to their *alumni*. Conversely, alumni can bring current knowledge and practices back to the universities. For providers of vocational training, the support of alumni is also a component for encouraging the transfer of training content to the company’s work processes. In particular, after they have completed an advanced course, access to learning material helps people to manage the changed requirements at the workplace. In both cases, the degree of success of transferring knowledge depends on the support from teachers or on sharing experiences with colleagues in a “Community of Practice“. It is clear that education providers have to offer

their alumni more than just structured access to digital learning content in the mid to long term. Personal networking in online social networks in combination with access to suitable content creates added value.

Learning object repositories do for educational institutions and educational providers what enterprise content management (ECM) systems do for companies: store and manage content in the form of media objects, and provide it to the people for whom it is intended. It becomes obvious that these functionalities are closely connected with the core processes in the education area. Apart from developing courses, communication and support in the learning process and certification (through examinations), teaching and learning are characterized by the provision of pedagogically structured knowledge elements. There is a clear need for the provision of digital learning material to be organized in a sophisticated manner and to be supported from a technical aspect if content is to be shared between providers and institutions – regardless whether this is based on a commercial business model or if the sharing is founded on mutuality and public interest. In view of the high expenditure that is associated with the production of media for teaching and learning, both users and providers see cost saving potential in reuse and also a market for sharing digital learning content. Hence, in the trend report “Learning Delphi“ the subject of “Content Sharing“ is deemed to have had a medium but consistent significance since 2007 (cf. MMB INSTITUT FÜR MEDIEN- UND KOMPETENZFORSCHUNG, 2009). But since 2009, content sharing is no longer a future trend but rather an established practice.

2 Evolution of Learning Object Repositories

The first learning object repositories (LORs) were built in the late 1990s, but wide acceptance was not immediate. From these experiences MCGREAL (2008) concludes that e-learning processes must have reached a certain level of maturity in institutions and content authors, instructors as well as learners must know about LORs to take full advantage of learning objects. In this section we briefly explain the evolution from virtual learning environments, through content management for digital learning material, to networked learning object repositories. We discuss typical repository functions and properties and provide a typology of LORs.

2.1 From Learning Management Systems to Distributed Repositories

Traditional system architectures to support e-learning are often still aligned to the principle that learners log on to a central system, a virtual learning environment, as single users from an Internet-capable PC. The development of distributed, networked LORs can be traced from this starting principle:

- Traditional virtual learning environments, also known as **learning management systems (LMS)**, are usually not designed to handle the tasks described in Section 1.2. They are intended as a platform for teaching and learning rather than a repository (cf. MAASS 2004, p. 5). The focus of management functions rests on the allocation of learners to teachers via courses, not the learning material itself. Typically, learning management systems organize course content in relation to a specific course: Digital learning content is often stored and managed in a local file system or database and

exists in the scope and time constraints of a course (which takes place at a specific time with a limited group of learners). Even transferring a learning module into a different course is a challenge that can only be managed by copying (if at all).

- **Learning content management systems (LCMS)** are more strongly aligned to the management of digital learning content; apart from the functions needed to organize learning, they also include functionalities to create and manage content (MAASS 2004, p. 16). Content management functions are oriented towards the workflows involved in the creation and provision of learning material (draft, release, publication, and revision) and to the life cycle of media objects (creation, revision, use, versioning, archiving). A cross-course LCMS allows learning material to be used in various courses – if necessary, also in a modular fashion in different combinations. Learning content management systems have been proposed as advanced alternatives to virtual learning environments if, especially in the company environment, the focus is on managing learning content. At the same time, for popular learning management systems the components for central content management have been enhanced. Learning content management systems can fulfill many requirements in terms of storing and managing digital learning content for individual education institutions and providers. However, they remain integrated in the learning management system of an organization and thus only allow sharing between the same virtual learning environments.
- Parallel to the development of learning content management systems (LCMS) standalone **learning object repositories (LORs)** have been developed and deployed (RICHARDS ET AL., 2002). They offer web access to digital learning material as a type of web-based learning module library or a sharing platform. Like in real libraries, the functionalities focus on the storage and provision of digital learning material. Therefore, learning objects that are stored can be enriched with metadata (keywords, specialist classifications, methodical categories) to help users find them. As opposed to an LCMS, which is linked to a virtual learning environment, a LOR supports different end systems in an organization, or it serves as a central sharing medium for partner communities. Often, in addition to user administration, repositories offer community functions to support sharing between authors. Also typical are functions that compile content into larger units. Learning object repositories do not offer an option to organize learning processes; however, there are individual solutions for popular virtual learning environments to integrate content from LORs.
- **Networking repositories operated by different organizations.** If an educational institution wants to increase the stock of resources accessible from within its standalone repository or aims to market its resources jointly with other LOR operators, networking of LORs is an obvious solution. Such a network allows digital learning material not only to be provided and managed locally, but also to be shared between institutions. The intricacies of networked repositories will be discussed in Part 2 of this article.

2.2 Functions and Properties of Learning Object Repositories

Learning object repositories have much in common with **document management systems (DMSes)**, which solve the problem of long-term storage of digital data, including access and version control. DMSes use folder structures, synchronize modifying accesses from

independent users to shared documents through check-in and check-out tools, include metadata management, and offer tools to ensure data security (cf. EPPLER 2005, P. 7). Often there is also an option to define document workflows. Nevertheless, there are some decisive differences to LORs. Document management systems handle physical files and folders that are processed with special application programs to view or change content, while LORs handle digital content objects that are usually displayed in a standard manner in a browser. Often such objects can even be manipulated in the browser.

We can describe **typical functions of LORs** by the categories management, provision, access, and use:

- **Management** includes the basic function for long-term secure storage of media objects and for keeping them available to be called up, including functions needed for data backup. Equally important are functions for data organization in directories or via metadata. Changes to the media objects also have to be reproducible with the use of version management and control.
- **Provision** includes the typical functions of searching, browsing, selection, and preview. Search functions include keyword search, full text search and advanced filter options. Structured metadata, both static and dynamic, are needed for efficient search processes. Static metadata refer to unchangeable properties of media objects and are generally compiled when such objects are stored. Dynamic metadata are acquired when objects are used. For example, they describe how often and in which context an object has been used, how long a learner viewed it in one session or which errors learners make.
- **Access** includes all functions for the allocation, description, and control of access rights. A key requirement here is differentiated user, group and rights management. User administration is also associated with roles in the work process (e.g., group administration, reviewers). Access also includes the description and management of licenses that are attached as metadata to individual media objects.
- **Use** includes the functions for handling media objects. Media objects are imported by authors or created in the system. They are available in a personal work environment, where they can, for example, be organized into collections of media objects that are currently relevant to the work environment. Use also includes functions to compile media objects into learning arrangements and make these available to the learners in virtual learning environments.

2.2.1 Creating learning arrangements and learning sequences

From an educational perspective merely aggregating media objects does not result in a learning process. Even an arrangement of media objects that is intended to impart knowledge (such as teaching texts, pictures, animations, exercises) and media objects that check knowledge (a quiz or a test) contain implicit instructions for the learners who are processing the corresponding learning unit in a self-study course: “Read the text, try to understand the pictures and animations, process the exercises and then perform the test.“ From an educational viewpoint, learning processes include many other forms of activities and tasks – especially when virtual learning environments are used for supervised online learning, for collaboration in the learning group, or in blended learning (KLEBL 2006). For

example, in problem-oriented learning, the learners process a specified case that covers a certain problem largely on their own. This methodology is aligned to specific steps (e.g., clarifying terms, defining problems, forming hypotheses). The aim is to make these steps explicit to the learning group in the form of work instructions. Normally, these learning steps structure the overview page of a course in a virtual learning environment. Retrieving learning objects from an LOR is necessary but not sufficient: there is also a need to manage complete learning arrangements in LORs.

2.2.2 Managing learning arrangements and learning sequences

If virtual learning environments are to be used widely and in the long term, it must also be possible to manage complete learning arrangements and make these available, in addition to digital learning material. This concerns finished courses, course sequences or parts of courses (for example, if certain parts of the course are taught in classrooms by tutors as disseminators, or if small groups get online support). The tutors should then be able to share specific workflows (e.g., the sequence of problem-oriented learning) and obtain these from common sources, which they then carry out parallel to or in sequence with different learning groups. This also concerns certain typical workflows in teaching and learning that are known as learning methods or learning scenarios, such as problem-oriented learning or the German “Leittextmethode“ (guiding-text method) used in vocational training. These established patterns of action with no reference to specific learning goals or learning content should also be stored and managed in a LOR – including sequencing in phases with references to generally applicable learning materials, tools, and communication services and with instructions and tips for learners and teachers.

2.2.3 Technical standards

When learning material and learning arrangements from LORs are used, the question of technical interoperability arises. If different technical systems are linked, such as a virtual learning environment with a LOR, it must be ensured that the content from one system can be processed in other systems, and ultimately on the user's PC. This is why technical standards for e-learning are important in the management and use of educational content (EHLERS & PAWLOWSKI 2006). There are several categories of standards:

- Technical standards for representing content, i.e., the **media objects** themselves. Media objects are often stored in standard formats such as MP3 (a popular audio file format) or AVI and MOV (video container formats). But even standard video containers and widespread browser plugins are no guarantee that one can play them. One also needs the specific codecs used for the video and audio in the container. Actual standards that every web browser is able to render, such as Java Applets, Adobe Flash, SMIL (Synchronized Multimedia Integration Language) or PDF, are also widely used.
- The **compilation** of individual media objects to larger units of learning, which are typical for e-learning, obeys standards, such as SCORM or IMS Common Cartridge. These specifications not only regulate the structure of the compilation (both with the IMS Content Packaging specification) and the structuring of metadata, but also the presentation of the navigation through the content, which is taken over by the virtual learning environment. Also common is the provision of aggregated content in the form

of a microsite. In this case, HTML pages with a few sub-pages and their own navigation are packed into a zip archive or a directory on a web server with no external links and can thus be displayed in any web browser without requiring any further tools. These standards need not necessarily be supported within a homogeneous system. Only when interoperability across heterogeneous systems is concerned they should better be observed.

- Even more specifically aligned to e-learning are standards that describe advanced **interactions** between users and the virtual learning environment. The IMS QTI (Question & Test Interoperability) standard is popular for standardized exercises and tests. IMS Learning Design is suitable for more complex learning scenarios. It is necessary to have a runtime environment that generates an executable test or course sequence from the raw data (usually in XML format).
- Technical and administrative standards that describe the **interfaces** between systems must also be mentioned. In 2003, the IMS Global Learning Consortium published the Digital Repositories Interoperability (DRI) specification with the aim of simplifying the integration of e-learning environments and repositories for digital content (IMS 2003). The specification includes recommendations for the design of interfaces for the central functions of repositories and is based on existing specifications such as IMS Resource Metadata.

2.2.4 Vendor independence

A variety of standards in e-learning are important for the platform-independent management of digital learning material and learning arrangements. Included are subject-specific formats to display content (e.g., MathML for mathematical formulas) and specific content elements, such as glossary entries, bibliographic references, and abstract descriptions of services for communication and cooperation. It is important that authoring tools, archiving and management systems as well as the virtual learning environments support these standards to enable sharing and prevent long-term vendor lock-in.

Based on common technical standards, functionalities of authoring tools, LORs, and learning management systems can be integrated into a standard system. Figure 1 illustrates the effect of typical user actions on the integrated sub-systems. The decomposition of the LOR sub-system into an area for managing workspaces, published learning objects and pedagogical scenarios is not typical. It is a special feature of the edu-sharing repository network, which will be described in Part II in more detail.

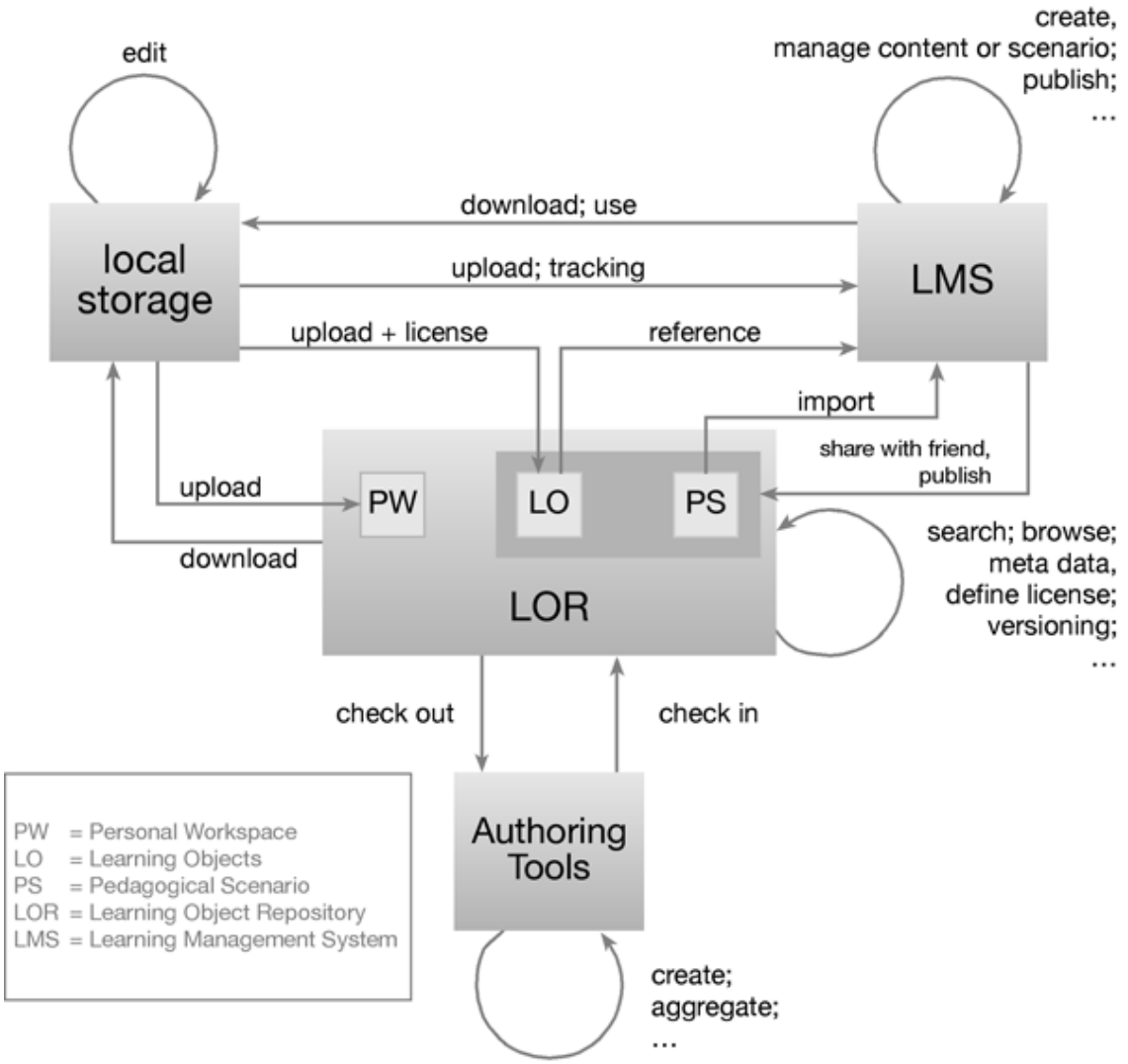

Figure 1: Interaction between device, LMS, LOR, and authoring tools in the context of typical user services

3 Typology of Learning Object Repositories

Existing LORs are distinguished by their basic approach and, based on this, their business and operating models (cf. MCGREAL 2008).

- **Repository or referatory:** In a repository, digital media objects are stored directly together with their metadata and are retrieved from there. A referatory only maintains information about content (such as metadata, evaluations, and user comments) together with links to the storage location of the content. Mixed forms allow both.
- **Discipline-specific or broad-based collections:** Repositories can be specifically aligned to specialist areas or even sub-disciplines (e.g., to gear systems as part of mechanical engineering) or can cover a range of subjects and disciplines (e.g., like the curricula at general education schools).

- **Open or closed user groups:** A repository that strictly limits user access to closed communities builds on relationships and trust between its users and, under certain circumstances, controls quality, payment, and copyright issues. Open repositories allow access to any user, so those issues are less regulated. A mixed form of repository is conceivable in which interest groups can create shared, protected work areas besides cooperating through the open section of the repository.
- **With or without content evaluation:** Repositories can implement quality control processes, such as peer reviews or user assessment. Other repositories admit a free sharing culture.
- **Provider or user focus:** Education providers and publishing houses can use or operate repositories to sell their professionally designed learning material. Other repositories aim to turn the recipients (teachers and learners) into producers – much in the spirit of Web 2.0.
- **Central or distributed architecture:** Typically a single, central repository is developed within the scope of an educational institution or a consortium that wants to share educational content. A central system for archiving and managing educational resources minimizes administration efforts including user management, information consistency, and access control. But centralized solutions are not always feasible or desired. For instance, if resource sharing between existing heterogeneous repositories is planned, the best solution is a federated architecture that links several repositories. In Part II of this article, we present necessities for a distributed resource management infrastructure and discuss their intricacies in detail.

In Part II we get back to this typology, extend it by further conceptual and technical requirements, and discuss selected systems, including Merlot, Connexions, LON-CAPA, Copendia, and the Blackboard Content System along these characteristics and requirements.

4 Summary and Outlook

“For what one has in black and white, one can carry home in comfort“
(Johann Wolfgang von Goethe, Faust I, verse 1966f)

If e-learning had existed at the time of German classicism, the assiduous student who collects digital learning content on the local hard drive would have been subject to Mephistopheles' mockery. However, even today learners generally have little choice but to download media products for their learning if they want to access them in the mid- to long-term. If learning content is contained in learning management systems, learners have access only for the time that the course runs, plus an unspecified time afterwards if necessary. Education providers that aim to provide better service integrate digital learning content tightly into their teaching aim to offer these media products sustainably to their students. Hence, they start to manage educational content systematically and independently of particular applications or learning environments. To this aim, Learning Object Repositories (LORs) provide storage capacity and adequate technical functionalities.

In this first part of our article, we presented technological and pedagogical requirements for Learning Object Repositories (LORs). Based on general quality criteria in information management, we outlined a framework that linked the principles of consistency, avoidance

of redundancy, access control and relevance to pedagogical goals. We then considered the evolution of LORs from learning management systems to distributed repositories, and described functions and properties as well as a typology of LORs. Here, we highlighted the need to manage learning arrangements and learning sequences along with educational content, and spotlighted the need for technical standards.

Starting from this view on requirements, we concentrate on technical solutions in the second part of this article. We examine distributed and networked system architectures for LORs in detail. We illustrate how the development of networked repositories is driven by the notion of reuse and sharing in the context of open education movements. Finally, we present our own architecture for a network of LORs called edu-sharing. This advanced example of a network of homogeneous repositories is discussed in comparison to related technology.

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References

ALFRESCO: Open source software for enterprise content management, 2005, http://www.alfresco.com/ (last check: 2010-11-24)

BENTLAGE, ULRIKE; GLOTZ, PETER; HAMM, INGRID: E-Learning. Märkte, Geschäftsmodelle, Perspektiven. Verlag Bertelsmann Stiftung, Gütersloh , 2001.

EHLERS, ULF D.; PAWLOWSKI, JAN M. (editor): Handbook on Quality and Standardisation in E-Learning. Springer, Berlin, 2006.

EPPLER, MARTIN J.: Wissensmanagement-Plattformen: Infrastrukturen für Wissensarbeiter. In: Hohenstein, Andreas; Wilbers, Karl (editor). Handbuch E-Learning, Cologne, Germany 2004, 5.5, 2003.

GESER, GUNTRAM (editor): Open educational practices and resources: OLCOS Roadmap 2012. Salzburg, Austria: Open Learning Content Observatory Services, 2007.

IMS GLOBAL LEARNING CONSORTIUM: IMS Digital Repositories Interoperability - Core Functions Information Model, Version 1.0 Final Specification, 2003, http://www.imsglobal.org/digitalrepositories/driv1p0/imsdri_infov1p0.html (last check: 2010-11-24)

KLEBL, MICHAEL: Educational Interoperability Standards: IMS Learning Design and DIN Didactical Object Model. In: Ehlers, Ulf D.; Pawlowski, Jan M. (editor): Handbook on Quality and Standardisation in E-Learning. Springer, Berlin, 2006, pp. 194-215

KRCMAR, HELMUT: Informationsmanagement. 4th edition. Springer, Berlin, 2005

LOCKYER, LORI; BENNETT, SUE; AGOSTINHO, SHIRLEY & HARPER, BARRY: Handbook of research on learning design and learning objects. Information Science Reference, New York, 2008

MAASS, WOLFGANG: Management von Lerninhalten durch Learning-Content-Management-Systeme. In: Hohenstein, Andreas; Wilbers, Karl (editor): Handbuch E-Learning, Cologne, Germany 2004, 5.6

MCGREAL, RORY: A Typology of Learning Object Repositories. In: Adelsberger, Heimo H., Kinshuk, Pawlowski, Jan M.; Sampson, Dimitrios G. (editor): International Handbook on Information Systems. Springer, 2008, pp. 5-28

MMB INSTITUT FÜR MEDIEN- UND KOMPETENZFORSCHUNG: MMB-Trendmonitor I/ 2009. Learning Delphi 2009. E-Learning 2.0 unterstützt Blended Learning. Weiterbildung und Digitales Lernen heute und in drei Jahren. 2009. http://www.mmb-institut.de/2004/ pages/trendmonitor/download/MMB-Trendmonitor_2009_I.pdf (last check: 2010-11-24)

RICHARDS, GRIFF; MCGREAL, RORY; HATALA, MAREK; FRIESEN, NORM: The Evolution of Learning Object Repository Technologies: Portals for On-line Objects for Learning. In: Journal of Distance Education, 17, 3, 2002, pp. 67-79

SCHULMEISTER, ROLF: Der “Student Lifecycle“ als Organisationsprinzip für ELearning. In: Keil, Reinhard; Kerres, Michael; Schulmeister, Rolf (editor), eUniversity - Update Bologna. Waxmann, Münster , 2007, pp. 45-77

VRIES, PIETER DE; BRALL, STEFAN & LUKOSCH, HEIDE: Fokussierung, Strukturierung und Vernetzung informellen Lernens in Unternehmen. In: bildungsforschung.org, 2009. http://www.bildungsforschung.org/Archiv/2009-01/Microtraining/ (not available at 2010-11-24)