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Digital Repositories: e-Learning for Everyone

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Introduction

Digital repositories, in the broadest sense, are used to store any digital material. However digital repositories for *learning objects* are considerably more complex both in terms of what needs to be stored and how it may be delivered. The term "learning object" is not intended to be restrictive but refers to any digital asset which can be used to enable teaching or learning. (For an in-depth discussion of learning objects see Wiley, 2000.) Neither does a learning object imply some specific size. It may refer to many different types of object from simple images or video clips, through complex questions, to collections of objects arranged in one or more sequences. In fact, an examination of the granularity of objects to be stored in a digital repository is a good place to start. If the objects are references to complete courses or substantial modules of courses then a digital repository is no more than a portal, a form of access to the material. What makes a digital repository much more than a portal is the ability to discover a learning object and put it to a new use. The purpose of a digital repository is not simply safe storage and delivery but *sharing* and *reuse*.

It might be argued that a digital repository is simply a digital library and the terms can be applied interchangeably. Over time, one term may become dominant but at present there is a subtle distinction to be made. A library is a place where resources are stored but librarians have control over what is to be placed in the library. Repositories, on the other hand, place a little more emphasis on the fact that they are places where people can contribute resources. The term repository is used here to emphasise the fact that many people may contribute learning objects to be shared among a community. Nevertheless, the metaphors of a library are familiar and apply very well to digital repositories.

The title of this paper “Digital Repositories: e-Learning for Everyone” implies that other forms of e-learning, the use of virtual learning environments or communications forums among others, is somehow less complete. The premise on which the title is based is that digital repositories, unlike most of the other forms of educational technology, do not force the participants into one particular approach but that many different people can support many different forms of teaching and learning using a single digital repository. In short – digital repositories are pedagogy-neutral. It is as likely that a lecturer preparing a classic lecture and handouts will find useful, and reusable, resources in a digital repository as it is that an educational technologist will find key resources for online courses to be taken by students in many different locations. Hence the “e-Learning for Everyone” in the title highlights that this paper aims to show that digital repositories can benefit all teachers throughout an organisation no matter how much or how little they adopt other forms of educational technology.

Although there is a wide spectrum of activity that can be described as e-learning, just as there are many types of learning activity that do not involve technology, it has been common to associate particular tools with particular forms of teaching and learning. This has been just as true of the blackboard, the OHP (overhead projector) and the flip chart as it is of the VLE (virtual learning environment), discussion board or CAA (computer assisted assessment). This paper examines different uses of digital repositories to show that they can be used to support much wider forms of learning than many more specific tools.

Uses of Digital Repositories

To define the possible uses of digital repositories it is useful to consider first who might use them and what educational processes might gain benefit from them. Users of digital repositories are often, but not always, teachers. They may produce web-based courses or classroom courses, face-to-face or distance-learning, full courses or short digital "nuggets". The digital repository should be neutral to the pedagogic purposes of the material just as a library has no influence over where or when a book is read, or whether it is used for a key educational purpose or to prop up the leg of a table.

Those who use digital repositories should not be concerned with their internal architecture. It is useful, therefore, to follow the approach of the IMS Digital Repository Interoperability Working Group (DRIWG) (IMS, 2001a) which is dedicated to establishing specifications to allow digital repositories to inter-operate while ignoring the internal architecture. This defines digital repositories in terms of what they can achieve.

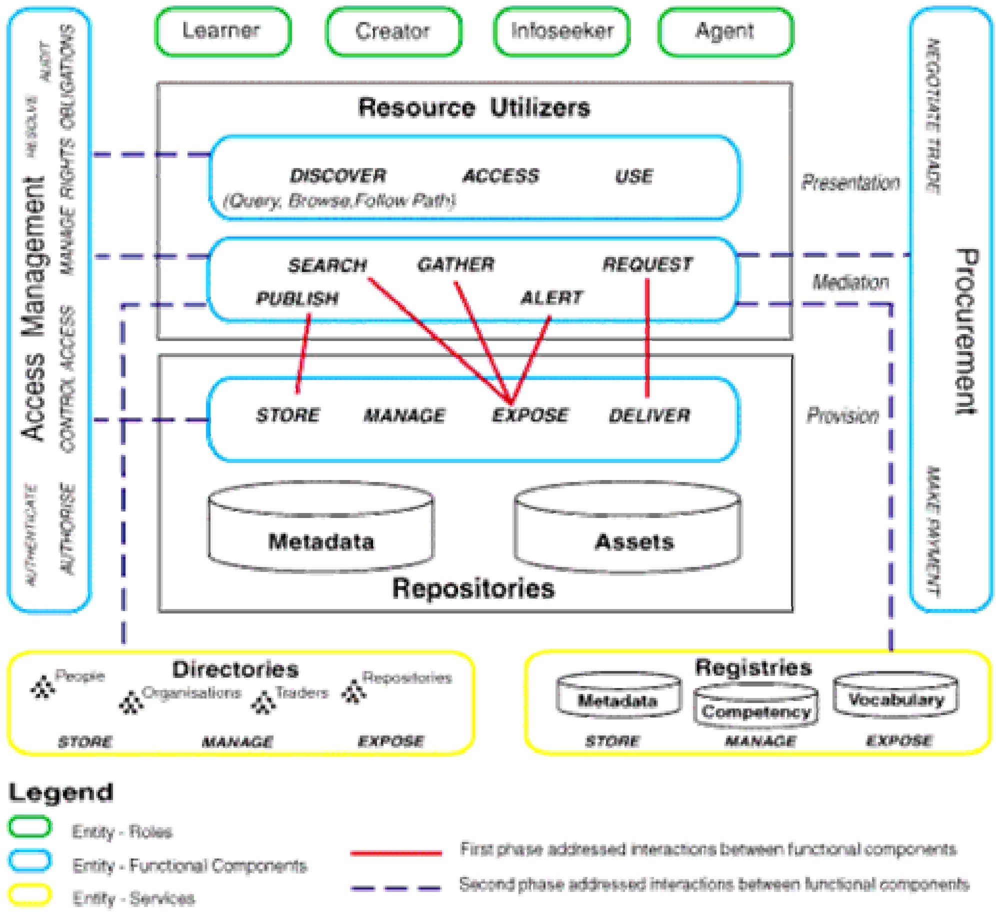

Figure 1: Digital Repository Interoperability Problem Space from IMS Digital Repositories White Paper, Version 1.6

Figure 1 shows the structure used within IMS where the lower box represents any type of digital repository while the upper box "resource utilizers" can be any person or system using these resources, divided at the top into learner, creator, infoseeker and agent.

The external services offered by this generic digital repository are *storage* of learning objects, *exposing* them by making available information about them, and *delivering* the objects themselves. The DRIWG goes one stage further than defining what services the digital repository can offer. It also specifies what services external "resource utilizers" might demand. While this is essential for the DRIWG to make progress it should be regarded as only a subset of the possible demands that "resource utilizers", let's call them "users", might make.

Who might those users be and what might they be trying to do when they realise that a digital repository is part of the solution? Some possible uses are:

A lecturer is looking for a diagram illustrating the effects of circulation of blood around the human body to include in a PowerPoint presentation in a lecture.
A tutor has developed a set of on-line resources about electoral processes for delivery in a VLE and wants to add some advice to students on how to prepare to give seminars illustrating the result of their project work.
A student is looking for an interactive simulation which can be used to determine the orbital characteristics of a satellite so that it can view polar regions at least four times daily.
A corporate training department wants to store all its on-line training material in one place in spite of the fact that much of it is used in many courses.

A school teacher wants to find a lesson plan that a colleague has produced for activities on a geography field trip.

The DRIWG has matched the tasks which users might undertake with the responses which digital repositories might make. This is shown in table 1which also shows additional tasks that human users might demand.

Task defined by use	Response of Digital Repository
Search, gather, alert, *browse*	Expose
Configure	*Interface change*
Request	Deliver
Publish	Store
Deliver (from one repository)	Store (in another)

Table 1: Tasks and the way a digital repository might respond (based on Digital Repository Interoperability Problem Space from IMS Digital Repositories White Paper, Version 1.6 but with items in italics added)

Now we will use the scenarios described above to explore the different ways in which the repository might be used.

A lecturer is looking for a diagram illustrating the effects of circulation of blood around the human body to include in a PowerPoint presentation in a lecture.

The lecturer logs into the departmental digital repository which presents a browsable interface based on the MESH, the Medical Subject Headings taxonomy (MESH, 2002). Since medics are familiar with this taxonomy the lecturer finds the section on blood circulation quickly and is presented with several items which appear to be suitable diagrams. Quickly pressing the preview button each to see which are suitable it is easy to download one that has the right amount of detail. Before leaving the digital repository the lecturer links it into the personal library under a customised taxonomy "First-year/Anatomy/Circulation" so that the diagram will always be available in that context.

A tutor has developed a set of on-line resources about electoral processes for delivery in a VLE and wants to add some advice to students on how to prepare to give seminars illustrating the result of their project work.

The tutor looks in the college library catalogue and enters search terms for "preparing presentations". The library catalogue returns several entries, some of which are paper-based handouts available in the college library while others have been found because the college library system has sent the request to a number of digital repositories around the institution. Some of these have returned mini-tutorials on preparing presentations and one of them is available for download as an IMS Content Package (IMS, 2001b). As the VLE the tutor uses supports this specification the package can be immediately downloaded and imported to add it to the lesson.

A student is looking for an interactive simulation which can be used to determine the orbital characteristics of a satellite so that it can view polar regions at least four times daily.

The student knows from previous searches that another university has a wide range of material on satellite orbits and goes to the digital repository at that university. Although he is not a registered user it allows searches and will permit access if the objects have appropriate copyright set. Unsure whether to search for satellite orbits or interactive simulations the student chooses an "advanced search" and finds that because the repository uses IMS Metadata (IMS, 2001c) it is possible to search for both simultaneously by searching for "satellite orbits" in the description, title and keyword fields while also searching for "simulation" in the learning-resource-type field. The student finds three interactive simulations and chooses the one that is described in "educational context" as suited to university education. As the student is working in a computer room in the university and wants to use the simulation from home that evening and then in another computer room the next day, it is best to leave the simulation in the digital repository so the student downloads its unique URL from the repository and places it in a university home page in order to get access from anywhere. Before leaving the repository the student completes an "alert" request which will send information by email about any new resources uploaded to the repository with metadata similar to the simulation that was found.

> A corporate training department wants to store all its on-line training material in one place in spite of the fact that much of it is used in many courses.

The training department purchases a digital repository and all trainers are asked to identify suitable files to upload. These files include handouts, presentations, animations, video clips, web pages and collections of web pages. In order to make the material easily searchable the corporation allocates a member of library staff to catalogue the entries. The librarian exports the classification system from the library system and imports it to the digital repository so that it can be used to catalogue learning objects but it will also inter-operate with the library database system. The librarian creates metadata for all the objects and initiates the library. The trainers find they can search all their colleagues' resources so spend less time on production (or in some cases duplication) of material and more time concentrating on how to use it. Some trainers find that they need to modify existing resources for their own needs so they download the original make the changes they need and upload the new version. Other trainers can see both versions and the descriptive differences between them.

> A school teacher wants to find a lesson plan that a colleague has produced for activities on a geography field trip.

The teacher is part of a "schools digital network" which includes a digital repository. After logging on the teacher searches for the lesson plan by using the name of the colleague. It becomes clear that this colleague is a prolific producer of lesson plans as the list is enormous so the teacher chooses a more advanced search and adds "geography, geology, fossils" to the keywords search. Once the lesson plan is located the teacher prints it and uses it on the field trip. The lesson plan is very useful so the teacher decides to add an annotation to the entry in the digital repository. This process allows people who use objects to add comments to each object so that others can use these comments as a form of quality control. While making a comment the teacher realises there are many other annotations for this particular lesson plan and resolves to check the annotations next time on each use of the digital repository.

Through examples the potential of digital repositories has been illustrated. These examples do not refer to a specific digital repository. Some repositories exhibit only a few of the characteristics described here. Not many include the majority of them. At the time of writing none offer all of these facilities.

Roles

The examples above show that there are many different roles involved in organising, managing and using digital repositories. One person can have different roles at different times. The roles digital repositories need to support are:

Librarian: The librarian is responsible for maintaining the core classification system of the library and for ensuring the integrity of metadata. A librarian will have wide-ranging power to edit and create metadata as well as to link and unlink objects to nodes of the classification system.
Contributor: Many people can act as contributors. In fact the most significant difference between a digital repository and a traditional library is the ease with which people can make contributions to a digital repository. These contributors of digital assets are often the best people to create the metadata associated with the asset but they may not always wish to do so.
Borrowers: Those who borrow regularly from the repository will want to have personalised taxonomies and have their own preferred interface. They may also wish to preserve the results of their searches from one session to the next.
Casual User: In some circumstances a guest may be permitted to search and browse as well as to download objects from a repository but without having their own personalised space. These guests may not even need to be registered users.

Administrator: An administrator has the responsibility of managing the users of the repository, creating new users and removing those who no longer need access. The administrator will also set the level of access which casual users are offered.
Software Agents: Agents acting on behalf of VLEs (virtual learning environments) or other digital repositories can also initiate queries and request downloads.

It will often be the case that contributors and borrowers are the same people. This is common when the repository is used as a shared resource among a team that creates digital assets and uses them to construct e-Learning courses.

In addition to these individual roles there is also enormous potential for groups of users to work together and have shared taxonomies, for example when one group is sharing responsibility for creating and teaching one course.

Practical Examples

One of the earliest examples of a digital repository conforming to interoperability standards was SeSDL (Scottish electronic Staff Development Library) (SeSDL, 2001, Campbell et al., 2001). This repository not only allows contributors to store learning objects related to staff development in HE and FE but enables these objects to be gathered together in the form of on-line lessons which are hosted by SeSDL, thereby removing the need for any technical expertise on the part of the teacher.

A commercial successor of SeSDL is intraLibrary, (Intrallect, 2002) a web-based digital repository that not only supports many of the facilities described above but also includes support for ZTHES (Z39.50, 2001), the Z39.50 thesaurus specification. This is used to specify a classification system and any classification system described in ZTHES can be imported into intraLibrary. These examples are reviewed by the Observatory on Borderless Higher Education (2002).

Other interesting examples of digital repositories include MERLOT (Multimedia Educational Repository for Learning and On-line Teaching) (MERLOT, 2000, O'Kane, 2000) and the Campus Alberta Repository of Educational Objects (CAREO) http://www.careo.org/, as well as perhaps the original object repository, Apple's Education Object Economy (http://www.eoe.org/) launched in mid-1997.

Importance of Standards

None of the scenarios outlined above would have been possible without the establishment of interoperability standards. The many different vendors and developers of educational technology have co-operated to establish some standards and they are working towards others which make it possible for learning objects created with one software application to be stored in a digital repository and later used by several other people each using different software applications. In this way there is no "proprietary risk" associated with deciding to follow a learning objects approach based on interoperability standards.

For storage, discovery and retrieval of learning objects from digital repositories the relevant standards are metadata, for describing the objects and content packaging for importing and exporting the objects. The workflow involved in creating, storing, discovering and reusing learning objects will now be summarised to highlight the relevance of the various interoperability standards.

Import: When a learning object is created it may be a single file (e.g. a video clip) or a complex collection of web pages each of which has interactive elements, images and possibly quiz elements. There are obviously also many alternatives between these two extremes. Some of the authoring applications are capable of "packaging" an object while others are not. A content package is a single compressed file (in .zip format) which contains all the *resources* needed for the learning object, a *manifest* listing all these resources and an *organisation* which describes how a student might view the resources. In fact, there can be several organisations since one set of resources may be useable in several different ways. The manifest also includes metadata, information describing the learning object, its ownership, potential uses, educational level, and much more. A digital repository needs to be able to import common content packages (ADL SCORM (2001), IMS Content Packaging (2001b)). It is also desirable that digital repositories can handle single files or collections of resources that have not been produced by applications which export “packages”. In this case the digital repository can import the file (or .zip) and create the metadata, and manifest within the repository.

Metadata: The metadata describing the learning object is crucial to its reuse as it is only through the metadata that a learning object can be discovered. It is essential, therefore, that all learning objects should always use consistent metadata fields. In some cases, for example when very simple files such as images are described, less metadata will be needed than for more complex learning objects which may be designed to meet very specific learning objects aimed at a particular educational level. The first true interoperability standard to be established was IEEE Learning Object Metadata (IEEE Learning Technology Standardization Committee, 2002, IMS Learning Resource Metadata Specification, 2001c). This contains more than 70 fields for describing learning objects and extends beyond the metadata specifications of Dublin Core (2001), commonly used by librarians, which is designed for bibliographic records rather than learning objects. Defining the required fields is only the first step in creating fully useful metadata (Schatz (2000)). The terms to be used in the fields are also vitally important since many people use different terms to mean the same thing. For example, the stage in education before children first attend school is described as “kindergarten”, “pre-school” and “early years” and probably many other terms. Some metadata fields may contain free text descriptions, such as the title or description of a learning object, while others contain only terms from a restricted vocabulary, such as those for “purpose” or “technical format”. It is important that communities who will share objects establish these restricted vocabularies through common agreement. Agreements of this sort have already been established in Canada (CanCore, 2002) and Singapore (Ng, 2002) and proposals are under way in the UK (Duncan et al, 2002, BSI 2002).

Among the most important vocabularies that need to be agreed are those for educational levels. These often vary from country to country and it is desirable to agree on “cross-walks” that allow metadata from one schema to be translated into that from another. (Heery and Manjula, 2000). There are also many widely-used classification systems, such as the Dewey Decimal System and the US Library of Congress System. It is highly desirable for learning objects to be classified (Wason, 2001) in many different ways simultaneously, for example a virtual reality model of the reconstruction of the Greek theatre at Pompeii could be classified under *discipline* as Arts/Performing Arts and Arts/Architecture but could also be History/Archeology and Technology/Virtual Reality while, at the same time, being classified by educational level as University/Archeology, High School/Theatre Studies and Further Education/CAD. Obviously the more places an object is classified the greater its potential for reuse.

Export: When a learning object has been identified as useful and a teacher plans to use it, there is a choice to be made about whether or not to take a copy of the object or use it dynamically from the digital repository. In the dynamic case a URL can be provided for the object which will always uniquely identify and make it available to any network-connected computer. On the other hand, if the object is to be downloaded onto a laptop and used in a tutorial group without access to a network it is more convenient to make a copy of the object. By exporting all objects from digital repositories in the form of standard “content packages” the additional work of a teacher is minimised. Any software application that can import a content package will understand the most complex of learning objects without any additional work.

This workflow is simply the most basic that a digital repository may need to support. Others, including searching by software agent and notification when changes occur, were outlined in the earlier scenarios.

There is a strong convergence between the educational community which is moving towards smaller, learning objects requiring careful collection and cataloguing and the library community which is moving towards storing much more digital material using their experience of cataloguing and classification. The synergy between these two disciplines is strong (Duncan and Ekmekioglu, 2003) and there are many lessons to be learned from the experiences of libraries in the digital world (Currier, S. (2001), Ekmekcioglu and Brown (2001))

Digital Object Economies

One of the most important changes that digital repositories are making to the way educators work is that they are beginning to establish "digital object economies". This phrase does not necessarily imply an economic basic for reusing objects, although charging mechanisms and digital rights management are certainly well advanced. Perhaps a "digital object exchange" might be a better term. It implies that digital objects become a kind of currency that people use to barter with. In effect anyone who belongs to such a community can expect to contribute a small number of digital objects and be able to share in a very large pool of resources. The larger the community the more beneficial this becomes.

A pessimist might well ask why such communities have not developed in the past since educational technology has been around for quite some time. The simplest answer is "granularity" (see (Duncan, 2003) for a more in-depth discussion). In the earlier days of educational technology, particularly when CD-ROM was the main technology, there was always a tendency to provide whole courses. In many cases teachers only need to use a part of that course, sometimes only a very small part. In other cases a teacher might want to use the course but some component is not appropriate for their students so they reject the whole course because it is not easy to separate the useful parts from the less useful. Now it is clear that teachers would value a CD-ROM full of small, reusable, learning objects that they could use, adapt and insert into many types of lesson rather than a single monolithic course.

The ability to find learning objects, disassemble them, modify parts and reassemble new objects comes form interoperability standards which define both how the objects are packaged and how they are described. Until now the objects that teachers can share and reuse have been restricted to "content": images, handouts, video, web pages, interactive models, quizzes. Now, however, we have the capability of defining and sharing pedagogic design in digital form (Koper, 2001). This means that teachers can exchange lesson plans as well as the material that will fit into those lesson plans.

Downes (2002a, 2002b) has described the potential for learning object economies superbly and makes an excellent case for the establishment of learning object economies to be at the heart of major educational initiatives.

In Scotland, the Learning Object Repository for Scottish Schools (LORSS) is a prototype of a system to establish a learning object economy among all school teachers in Scotland fully exploiting the broadband connectivity of all Scottish schools. The success of this programme depends on much more than the infrastructure and the software tools, it depends on the people who will form the community. Digital repositories have made learning object economies possible, communities will determine if they will be successful, the signs are good.

Conclusions

The question of whether or not digital repositories offer "e-learning for everyone" has been examined through examples. Whether the use of digital repositories is tied solely to web-based delivery of e-learning, or is widely used to support all forms of learning based on digital material, depends on the mode of use and not on the technology. Digital repositories adhering to interoperability standards are flexible enough to support teaching and learning and it is up to the teachers and learners to define how the repositories are used. While it is possible to use a digital repository as a hidden resource which responds only to calls for learning objects from VLEs, it is also possible to use a repository in a manner very similar to a traditional library in which resources are arranged in categories and browsing through the "shelves" can be very rewarding.

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