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ARTICLE

Preservation of Learning Objects in Digital Repositories

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Abstract

The aim of this article is to analyse the different processes involved in the preservation of learning objects in a digital repository. Presented as a case study is a prototype repository for a collection of statistics-related e-learning materials used in the respective academic subjects offered by the Open University of Catalonia (UOC, Universitat Oberta de Catalunya). The purpose of these materials is to serve the whole community and not just the university. To that end, the repository was created with DSpace open-source software. The goal is to promote the reuse and the digital preservation of such e-learning materials, though certain aspects of these two objectives are somewhat contradictory. This article analyses the requirements of learning objects deposited in a repository and the needs of the various roles intervening in their handling and long-term preservation.

Keywords

learning objects, repositories, digital preservation, metadata, archives, digital libraries

Preservación de objetos de aprendizaje en repositorios digitales

Resumen

El propósito de este artículo es analizar los diferentes procesos en la conservación de objetos de aprendizaje en un repositorio digital. Como caso de estudio se presenta un prototipo de repositorio basado en una colección de materiales de e-learning sobre estadística, usados en las asignaturas respectivas de la Universitat Oberta de Catalunya. Estos materiales tienen el propósito de servir a toda la comunidad, no tan solo a la universidad. Para ello, se ha creado este repositorio en una plataforma abierta basada en DSpace. El propósito es promover tanto la reutilización como la conservación digital de dichos materiales de e-learning, aunque ambos objetivos son, en ciertos aspectos, contradictorios. En este artículo se analizan los requerimientos de los objetos de aprendizaje depositados en un repositorio y las necesidades de los diferentes roles que intervienen en su manipulación y su conservación a largo plazo.

Palabras clave

objetos de aprendizaje, repositorios, preservación digital, metadatos, archivos, bibliotecas digitales

1. Introduction

In many higher education institutions, there is a growing tendency to use Virtual Learning Environments (VLEs). In a VLE, every aspect of a course is managed via a Consistent User Interface (CUI), which is normally standard across the institution. One of the usual components of a VLE is a learning object repository, which is employed to manage teaching resources used throughout the course. There is no common definition of the repository concept (Conway, 2008), though it could be said that repositories are openly used to provide a specific community with materials or information. Among other resources, an institutional repository (Shreeves & Cragin, 2008) usually includes reports, publications, complete courses and manuals. It may also include learning objects and research project data, labelled in accordance with a metadata schema, preferably IEEE LOM or Dublin Core (Neven & Duval, 2002).

Digital preservation is a key element of repository design, given that the aforementioned resources are created with a specific software version and need to be updated to ensure that they can be accessed at a later date for as long as necessary. To do otherwise would mean that information might be lost.

It also entails the need to perform a risk assessment on such resources to establish the priorities of digital preservation operations. A risk assessment can also serve to assess whether the cost of digitally preserving software versions or out-of-date learning materials is acceptable.

Furthermore, owing to the considerable variability of the elements that can be found in the learning process, be it in terms of type (exercises, examples, simulations, etc.) or format, the specific characteristics of learning objects used in a VLE make it necessary to reconsider the usual preservation mechanisms connected with metadata labelling.

This article is structured in the following manner. The second section describes the pilot repository taken as the case study in order to analyse a digital preservation solution based on DSpace. The

third section describes the elements that need to be taken into account in order to establish the necessary criteria to assure the preservation of the deposited objects. The fourth section presents the preservation policies applied to the repository. Finally, the conclusions drawn from this project, as well as the present and future lines of work, can be found in the fifth section.

2. Open digital repositories

The Open University of Catalonia (UOC, Universitat Oberta de Catalunya) has created an open digital repository[1] containing a collection of statistics-related learning materials, in line with a user-centred design approach (Ferran et al., 2009). These learning materials take the shape of exercises, study materials, multimedia documents and specific statistics program data files.

These resources come in a wide range of formats, including Minitab, Word and Portable Document Format (PDF), although there is a growing number of teaching materials in video and other formats (both text and data), all of which have been created using multiple software and operating system versions. Given this considerable variety, it is necessary to think about the repository from the viewpoint of both learning material management and long-term digital preservation (Smith, 2005).

Since its creation, the UOC has generated a considerable number of statistics-related teaching resources. These resources have been created by means of a high-quality publication process involving various roles (authors, editors, lecturers, managers, etc.), and have been published in line with an editorial, design and production model based on modules. These modules are learning units – each having a small number of credits – designed for learning about a specific topic of course content. The process of creating and editing them takes about a year. Maintaining and updating them to reflect any changes is a costly, complex process, since it means that either the whole or part of the editorial process has to be repeated. Other types of resources associated with the materials in question also need to be managed in the same way. These associated resources are generated by teaching activities that take place in each academic semester, and include examples, exercises, experiments and self-directed learning exercises.

In this repository, the concepts inherent to a digital library and to reference services have been applied to an e-learning environment. Aspects such as searches and library services are similar though not identical. In a digital library, students are accustomed to searching for information by author and title. However, when it comes to learning objects, the titles of exercises, files and learning units are frequently duplicated. Consequently, given that the concept of title is ambiguous, a different taxonomy for their classification needs to be used.

The repository allows students and other people forming part of the learning community to have access to educational materials in an organised way. Regarding the case in hand, the materials were found to be spread across various academic subjects, inaccessible to the community as a whole, and neither classified nor ordered. Consequently, many students were at a loss when it came

1. http://oer.uoc.edu (currently under development).

to using these resources, and lecturers did not get the benefits they had hoped for (Barker et al., 2004). In addition, there were no suitable search criteria to be able to identify those resources that could be reused to create new educational materials. Exercises, notes, modules, articles, text books, software tools, virtual laboratories, audio resources, videos, curricula, timetables, calendars, activities, simulations and learning objects, among many other documents, are more accessible if a digital repository is used.

2.1. DSpace

There are many reasons for choosing DSpace[2] as a repository application. DSpace open-source software is a repository application that accepts various metadata schemata, incorporates long-term preservation policies, uses handles to identify each element forever, and is solid and stable. Equally important is the fact that it is in use in other parts of the UOC. As an open-source software application, DSpace has a large, active community of users and developers, including higher education institutions and digital libraries. DSpace is also suitable for long-term digital preservation because it accepts policies with that goal in mind. It includes tools like Checksum Checker, which allows the integrity of storage area bitstreams to be verified, and TechMDExtractor, which allows the formats of stored bitstreams to be validated and metadata to be extracted from bitstreams. It also includes a pre-ingest workflow step and an optional workflow that validates the format of each bitstream after ingest, thus providing the administrator with the metadata of invalid or badly formed files.

DSpace has communities and sub-communities (defined hierarchically), collections, items, bundles of bitstreams and bitstream formats. In terms of the data model, communities and sub-communities are top-level, whereas a collection is a set of items, such as statistics-related resources. Each collection has its own workflow, which can be defined by the management unit. An item is a useful set of content and metadata, added during the ingest process or later. Regarding storage, a bitstream is a stream of bits corresponding to the content of metadata files, whereas a bitstream format involves the capture of specific formats of files ingested, which can be improved using metadata extraction tools like DROID[3] or the NLNZ Metadata Extraction Tool[4].

By default, DSpace uses Dublin Core metadata to archive collections. However, in the ingest process, other metadata used for the long-term preservation of an object can be added. A fuller description allows for better retrieval of objects from the repository and the enhancement of their properties, identifying how an object was created and other similar data. Furthermore, an analysis of the usage of objects deposited in the repository allows metadata to be continuously enhanced (Ferran et al., 2007) by identifying and correcting labelling problems.

2. http://www.dspace.org
3. http://droid.sourceforge.net
4. http://meta-extractor.sourceforge.net

3. Digital preservation

The key issue is whether access to these materials will still be possible in a specific period of time, say in 20 years from now (the UOC was created just 15 years ago and has already encountered preservation problems). The technological obsolescence of statistics program files in this case has to be monitored to prevent any loss of information, thus minimising any potential risk. This means that digital preservation has to be considered from the viewpoint of information accessibility over time. The long-term preservation of these digital objects requires a risk assessment to establish priorities and a preservation plan to facilitate access to them. These elements will ensure that learning materials, among others, can be reused.

At the UOC, repository ingest processes usually take place in January and July, after (and before) each academic semester. At these times of the year, the repository has to be technologically analysed to assess the need to migrate existing digital objects towards later versions of software.

Before deciding which types of materials to store, a risk assessment needs to be performed to ascertain obsolescence risks, to establish priorities in the preservation plan and to determine the digital preservation costs that the institution can bear.

By performing a risk assessment, it is possible to establish which materials are less costly to re-edit and more economical to preserve. Such an assessment particularly takes account of software version IDs that are capable of supporting certain materials. In our study, we based the risk assessment on technological obsolescence.

One of the instruments available for repository risk assessment is DRAMBORA (DCC, DPE, 2007), which allows the risks associated with a repository's materials to be assessed and quantified.

The DRAMBORA method, which is based on the AS/NZ 4360:2004 standard, allows the environment and the digital resources to be assessed. DRAMBORA is applicable to digital collections that are, or are going to be, in repositories (McLeod, 2008). In the assessment of digital resources, their preservation priorities can be established.

DRAMBORA, a methodology applicable to open repositories, comprises six stages: identifying the organisational context; documenting the regulatory framework; identifying repository assets, activities and their owners; identifying the risks; assessing the risks; and managing the risks.

In addition, a radar chart can be created at the end of the process. This allows our statistics-related repository to be compared against the mean of other similar repositories.

One of the main questions is how to store materials created digitally by various types of institutions. Institutions need to store their digital information for a wide variety of reasons: administrative, legal, historical, personal, scientific value (scholarly articles, electronic theses, dissertations, etc.), and, of course, teaching. Such insitutions include universities, schools, libraries, museums and research centres, as well as people who want to have their own private collections of materials. This implies not only the meticulous management of technology, but also the ability to access old electronic documents with new technology (Lee et al., 2002). This is where digital preservation comes in. Such preservation makes electronic data accessible and useful for a long period of time. Electronic data should preserve their significant properties over time and be acessible to a designated community of

users. Long-term preservation means that electronic materials will be available in the future, retaining all of the significant properties they had when they were created.

3.1. Preservation in a digital repository

As mentioned earlier, digital preservation techniques need to be applied to ensure that learning materials are accessible to students and lecturers over time. The most common preservation strategies are migration and emulation. Some examples are VERS Encapsulated Object (VEO) (Waugh et al., 2000) and Universal Virtual Computer (UVC) (van der Hoeven et al., 2005), respectively.

Migration is the process of converting an electronic object into a higher version of its file format to make the information easier to access and handle. In the migration process, some significant properties may be lost (owing especially to software conversions), so information descriptions in the ingest process must be precise. The main objective of migration strategies is to retain all of the significant properties that a digital object had when it was created. An example would be the migration of Lotus Notes spreadsheets to Microsoft Excel or, better still, towards a standard XML file.

Emulation is the process of creating an environment towards which obsolete software must migrate so that it can function on a new platform. The new software will subsequently need to migrate when the simulator becomes technologically obsolete. Emulators for old games consoles like Atari and Sony PlayStation are well known. This means preserving the appearance of the platform and its functionality, and having an updated copy of the original object.

Finally, another approach to long-term preservation is the Open Archival Information System (OAIS) model, which has been adopted as ISO 14721:2003 (CCSDS, 2002). The main objective is to preserve information and make it available to a designated community indefinitely. The OAIS model is now a reference standard for archival systems.

3.2. The OAIS reference model

The OAIS model is widely accepted by institutions as a digital and non-digital archival model. The OAIS model is defined as: "an archive, consisting of an organisation of people and systems, that has accepted the responsibility to preserve information and make it available for a designated community".

It is based on information processes that facilitate a high-level information description of the objects managed by an archive or repository. The functional components of a digital archive are ingest, information storage, preservation planning, access, data management and administration. The OAIS model has three actors: producer, consumer and manager.

The producer is defined as the role played by those persons, or client systems, who provide the information to be preserved. This can include other OAISs or internal OAIS persons or systems.

The consumer is the role played by those persons, or client systems, who interact with OAIS services to find preserved information of interest and to access that information in detail. This can include other OAISs, as well as internal OAIS persons or systems. One class of consumer from the designated community should be able to understand the preserved information.

The manager is defined as the role played by those who set overall OAIS policy as one component in a broader policy domain. In other words, control of OAIS management is only one of the management responsibilities.

Management is not involved in the day-to-day operation of the archive. It can assign policies to the repository like, for example, the change of role of both producer and consumer. Figure 1 shows the OAIS model, in the form that the definition of the classic digital library model is understood. In this case, producers create content and, through a management workflow, consumers can retrieve content developed by producers.

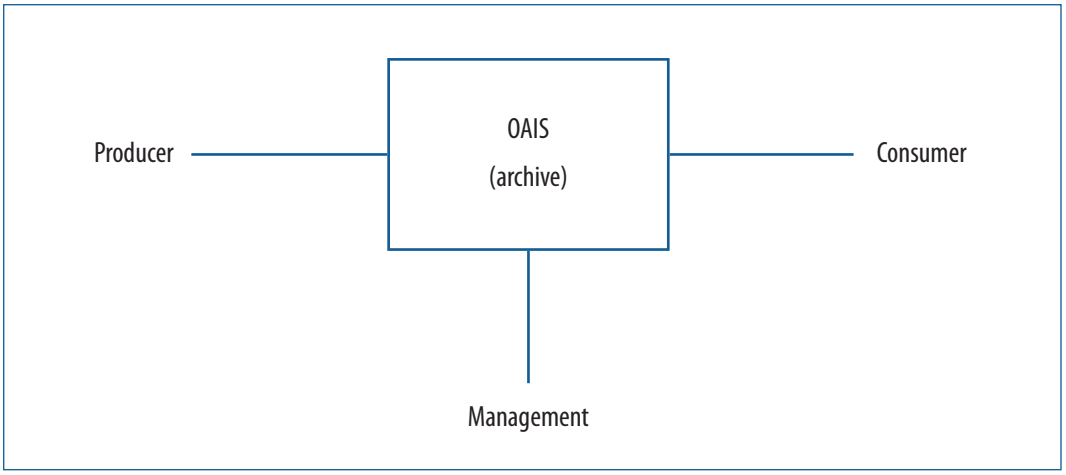

Figure 1. OAIS model reprinted with permission of the Consultative Committee for Space Data Systems.

The information is stored and managed in the OAIS archive. Consumers and producers of the designated community interact with OAIS services to find and acquire preserved information of interest.

The OAIS model allows workflows to follow each other in a new digital archive. Its implementation means that clear standards for digital preservation are required. So too is the creation of a set of terminology that can be understood by the designated community, and the clarification of procedures to make a reliable archive service available.

The functional components of a digital archive are ingest, information storage, preservation planning, access, data management and administration.

Ingest is defined as an open archival service. It is the process of a digital object's acceptance by producers and selected consumers in accordance with the concept of collaborative learning, and its entry into the digital archive. In our model, the ingest function includes the receipt of Submission Information Packages (SIPs) from producers and selected consumers, and the preparation of content for storage and management in the archive.

Archive storage facilitates Archival Information Package (AIP) services and functions.

Planning and preservation facilitates services and functions to ensure that the information stored in the OAIS remains accessible to the designated community in the long term, even when the computing environment is obsolete.

These actors are involved in some of the functional components. In a VLE, there may be a vision that differs from the OAIS model, in which the three actors have clear-cut roles. This is because all the roles are interchangeable in a VLE. Lecturers and students can be producers and consumers at one and the same time. Lecturers can be producers, consumers and managers. To give an example, a student may solve a statistics problems and the lecturer may consider it an appropriate solution to include in the repository, thus playing the role of manager. In the OAIS model, this variant can be defined through the management of workflows (Chen, 2004) that DSpace supports.

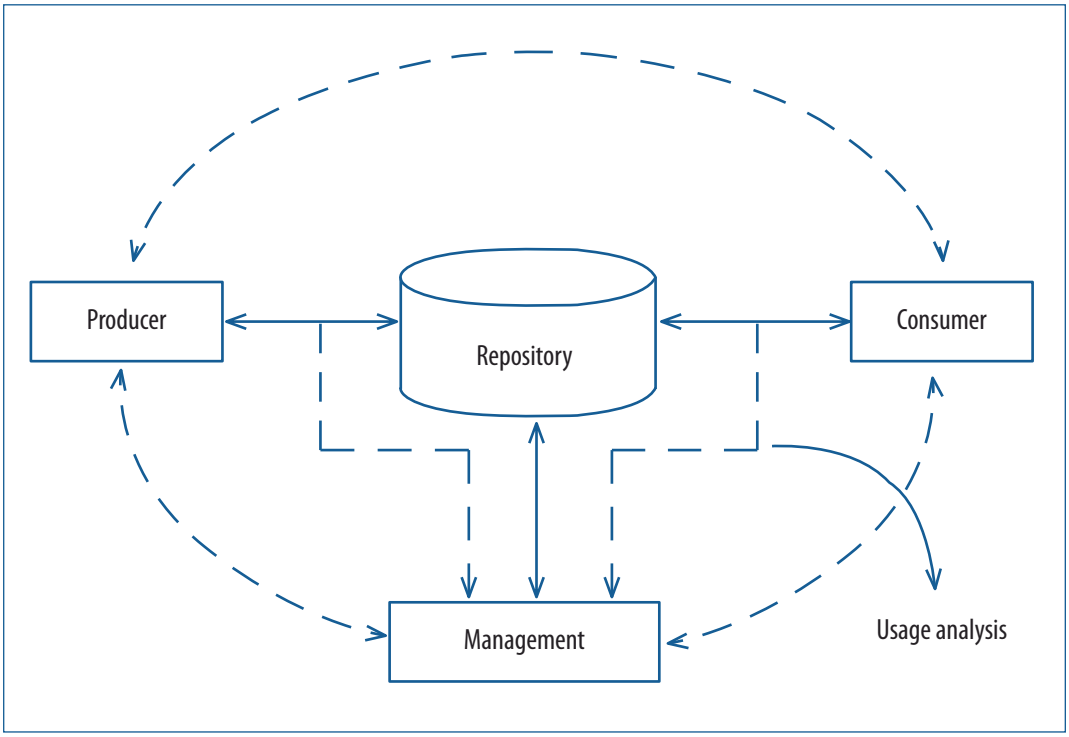

Figura 2. OAIS model in a VLE

Figure 2 shows a possible scenario for the OAIS model in a VLE, in which producers can play the role of consumers, and consumers can play the role of producers. Given that the workflow can be configured in the repository, it is possible to assign management rights to both producers and consumers.

If we apply the Web 2.0 concept to our Open Educational Resources (OERs), concepts such as collaborative learning and community participation in a classic OAIS model may change, as shown in Figure 1. It is also important to note that usage analysis is enhanced (Lee, 2002). Usage analysis would serve to switch between producer and consumer roles depending on resource usage.

4. Preservation plan for teaching materials

Before preserving a learning object, it is essential to know what its significant properties are, and especially those that make the object reusable, like file format, for example. The collection of statistics-

related resources that may become part of the repository includes MPEG videos, Microsoft Excel files, Minitab files, SPSS files, text documents, LaTeX documents, various versions of Microsoft Word files, PDF files, Microsoft PowerPoint presentations and, more recently, multiple versions of OpenOffice files. For example, files in proprietary code, such as SPSS, or Minitab files with associated formulas, pose one of the main challenges. Minitab files can be exported to XML or tagged files, whereas SPSS is the *de facto* standard in preservation formats.

4.1. Significant properties

Significant properties are characteristics of digital objects that need to be retained to ensure that they are accessible in the long term (Ashley, Davis & Pinsent, 2008). Significant properties can be classified into content, context, appearance, structure and behaviour. For reasons of space, this article will only examine those aspects connected with the first category. A metadata file description is required to preserve files. These metadata enhance the description of objects ingested into the repository. Metadata should be subject to a quality control check to prevent any noise in the retrieval process.

Prior to ingest, all the materials should be checked to ensure their preservation and their technological reusability. So, for example, the tags in a PDF/A file should be carefully checked to validate that the file format is correct and consistent. It is advisable to have two versions of various materials: one accessible to the public for versioning and usage data collection (Ferran et al., 2007), and one set aside for managers for long-term preservation, though both are linked via metadata. The versions for long-term preservation should be migrated to make them accessible before they become technologically obsolete, as soon as any problem connected with the accessible version is found. Thus, before an ingest, a file format description needs to be created and stored in the format metadata, while attempting to separate, as much as possible, the content descriptions from the descriptions of other significant properties, such as their appearance, for example. This process could be partially automated, since manual intervention represents a high cost that is unsustainable for large volumes of resources.

4.2. Format assessment for long-term preservation

Finally, another aspect that needs to be considered is file format sustainability. In the UOC's case, materials have been created digitally, albeit with hardcopy versions in mind. This situation shows that even with a wide variety of formats, the most important materials (from a teaching viewpoint) are created in PDF format. While this is acceptable to students, it limits the handling of such materials. However, in the process of ingesting learning objects into the UOC's repository, it is found that, owing to the wide variety of documents, some format migrations need to be carried out to simplify preservation needs and to reduce technological requirements. This is done in line with the following non-exhaustive criteria:

Portable Document File: PDF/A, based on PDF Reference Version 1.4. ISO 19005-1:2005, considered to be a standard.

Microsoft Word: converted into PDF/A or OpenOffice format. Account should be taken of the fact that a file may contain macros and/or formulas.

Microsoft Excel: converted into XML or OpenOffice formats.

Video: migrated to MPEG-2, AVI or QuickTime formats.

LaTeX documents: preserved in the original format but, in the long term, in DocBook XML with embedded MathML.

Images: converted into PNG, TIFF or JPEG formats.

PowerPoint files: converted into PDF/A or OpenOffice formats. Interactive sequences should be documented.

Audio file: converted into WAV or MP3 formats.

Minitab files: converted into XML format.

SPSS files: converted into SPSS portable (*.por) or XML formats.

Thus, in order to ascertain the priorities with regard to formats, we have taken the list of possible risk identifiers facilitated by DRAMBORA as the basis. While not exclusive, these identifiers are mainly the following:

- R11 (fails to preserve essential characteristics of digital information)
- R31 (software failure or incompatibility)
- R33 (obsolescence of hardware or software)
- R34 (media degradation or obsolescence)
- R66 (preservation strategies result in information loss)

In our case, these identifiers have allowed us to establish priorities with regard to migrating formats due to their technological obsolescence or versioning. They have also allowed us to ascertain what risk is acceptable in the interpretation of the risk.

After assessing the potential risks with regard to technological obsolescence, it was possible to establish a relationship between migration processes and the cost of implementing them.

As mentioned earlier, in format migration operations, the cost of converting a Microsoft Word file to PDF/A format differs considerably from the cost of video file migration operations.

In the video migration process, other substantial changes in the significant properties may occur, such as the loss of resolution, the deterioration of audio or the time established in the migration operation.

5. Conclusions

This article has presented an analysis of the preservation needs of learning objects deposited in an open educational repository, specifically in relation to a collection of statistics-related materials created by the UOC. This repository, which is based on DSpace open-source software, promotes the reuse of educational materials and their long-term preservation.

Before implementing digital preservation operations, operation priorities are established by using the DRAMBORA repository risk assessment methodology.

DRAMBORA has allowed us to establish priorities in the preservation plan, the aim of which is to prevent technological obsolescence. As a result of the assessment, we have been able to establish a relationship between costs and migration operations to help us decide which materials can be migrated without any major alterations to their significant properties.

The wide range of formats currently used to store learning objects means that long-term preservation strategies need to be established to ensure that such objects can be retrieved in the future, especially when taking account of the considerable variability of technology and the specific labelling needs of content used in a VLE, which are different from those of a digital library or an institutional repository. It is therefore necessary to choose formats that guarantee some degree of continuity and thus facilitate preservation policies, such as PDF for documents and XML for data files, although certain formats (video, images, etc.) need to be described with additional metadata for their subsequent retrieval or conversion in the event of their obsolescence. The use of open file formats based on open-source tools also enables some degree of preservation through emulation techniques, so long as the existing source code can be compiled and executed. In this respect, the existence of a software package like OpenOffice offers a combination of both elements: description using XML and the possibility to access the source code.

Today, the main challenge is to define semi-automated mechanisms to enable the proper labelling and processing of the thousands of learning objects that the institution has, without it resulting in a cost that is too high to bear. Likewise, the introduction of preservation policies entails taking a fresh look at the organisational aspects of the institution because such policies involve very different groups that have very different goals. This means that complex workflows will need to be established, bearing in mind that other actors may play the role of content producers. Moreover, as is the case in any contingency plan, it is essential to establish timelines, with simulations to periodically assess the obsolescence of content stored in the repository. Finally, we hope to make the preservation policy of the institutional repository publicly available in the near future.

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References

ASHLEY, Kevin; DAVIS, Richard; PINSENT, Ed (2008). *Significant Properties of E-Learning Objects* [online]. [Accessed: 20 November 2010]. <http://www.jisc.ac.uk/media/documents/programmes/preservation/spelos_report.pdf>

BARKER, Ed [et al.] (2004). *Long-Term Retention and Reuse of E-Learning Objects and Materials* [online]. [Accessed: 20 November 2010]. <http://www.jisc.ac.uk/whatwedo/programmes/preservation/elo.aspx>

CCSDS (2002). *Reference Model for an Open Archival Information System (OAIS). Blue Book* [online]. [Accessed: 20 November 2010]. <http://public.ccsds.org/publications/archive/650x0b1.pdf>

CHEN, Su-Shing (2004). "Digital Preservation and Workflow Process". In: *Proceedings of the 7th International Conference on Asian Digital Libraries. Digital Libraries: International Collaboration and Cross-fertilization*. Vol. 3334, pages 61-72.

CONWAY, Paul (2008). "Modeling the digital content landscape in universities". *Library Hi Tech*. Vol. 26, No 3, pages 342-354.

Digital Curation Centre and DigitalPreservationEurope (2007). *DCC and DPE Digital Repository Audit Method Based on Risk Assessment v1.0*. [Accessed: 20 November 2010]. <http://www.repositoryaudit.eu/download>

FERRAN, Núria [et al.] (2009). "User Centered Design of a Learning Object Repository". In: *Proceedings of the 13th International Conference on Human-Computer Interaction. Lecture Notes in Computer Science*. Vol. 5619, pages 679-688.

FERRAN, Núria [et al.] (2007). "Enriching e-learning metadata through digital library usage analysis". *The Electronic Library*. Vol. 25, No 2, pages 148-165.

Van der HOEVEN, Jeffrey; van DIESSEN, Raymond; van der MEER, Kees (2005). "Development of a Universal Virtual Computer for long-term preservation". *Journal of Information Science*. Vol. 31, No 3, pages 196-208.

LEE, Kyong-Ho [et al.] (2002). "The State of Art and Practice in Digital Preservation". *Journal of Research of the National Institute*. Vol. 107, No 1, pages 93-106.

MCLEOD, Rory (2008). "Risk Assessment; using a risk based approach to prioritise handheld digital information". In: *Proceedings IPRESS 2008*. <http://www.bl.uk/ipres2008/presentations_day1/20_McLeod.pdf>

NEVEN, Filip; DUVAL, Erik (2002). "Reusable learning objects: a survey of LOM-based repositories" [online]. In: *Proceedings of the Tenth ACM international conference on Multimedia*. Pages 291-294. [Accessed: 20 November 2010]. <http://www.cs.kuleuven.ac.be/cwis/research/hmdb/publications/files/Lorsurvey.pdf>

SHREEVES, Sarah; CRAGIN, Melissa (2008). "Introduction: Institutional Repositories: Current State and Future". *Library Trends*. Vol. 57, No 2, pages 89-97.

SMITH, MacKenzie (2005). "Exploring Variety in Digital Collections and the Implication for Digital Preservation". *Library Trends*. Vol. 54, No 1, pages 6-15.

WAUGH, Andrew; WILKINSON, Ross; HILLS, Brendan (2000). "Preserving Digital Information Forever". In: *Proceedings of the Fifth ACM Conference on Digital Libraries*. Pages 175-184.

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