Report

S-TEAM

Report

Web-based distribution of teaching and professional development resources

October 2010

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Report on Authoring, Storage and Delivery of Digital Learning Resources

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1. Digital learning resources

This chapter aims to provide a general overview of digital learning resources. We start by discussing the various definitions which have been used throughout the years. The report continues by explaining that there has been a paradigm shift and giving a brief historical overview about digital learning resources. This is followed by a summary of recent trends. The following four sections focus on technical issues such as types of digital learning resources, learning technology standardization, learning resource authoring tools and repositories. The ninth section focuses on the copyright issues and shift to the use of open content licenses. Finally we conclude this chapter by discussing possible promotion strategies and scenarios for the use of digital learning resources.

1.1 Defining digital learning resources

Various terms are used when talking about digital learning resources. In the technical and research community it is common to talk about learning objects. In the educational community and teacher training, people prefer to use less technical terminology and talk about digital learning resources or educational resources. In the recent years there is also a lot of discussion about open educational resources. In this section we will discuss these various definitions.

Learning objects

The term learning object is first mentioned in 1992 when a well-known e-learning expert, Wayne Hodgins, was watching one of his children playing with Lego blocks. Hodgins realized that the similar building blocks could be used for creating digital learning resources. He started to call these building blocks *learning objects*. The term was first officially used in 1994 when the CedMA working group was titled “Learning Architectures, APIs and Learning Objects” (Polsani, 2003).

One of the first attempts to define learning objects is from 1997 when James J. L’Allier defined learning object as “the smallest independent instructional experience that contains an objective, a learning activity and an assessment” (L’Allier, 1997).

The most prominent definition of learning objects comes from the IEEE Learning Object Metadata standard, completed in 2002. It defines learning object as “any entity -digital or non-digital- that may be used for learning, education or training” (IEEE, 2002). A similar definition has been used since the first draft versions in 1998.

This definition has been criticized because of its too broad scope. Depending on the context, almost anything can be considered as a learning object. In 2000 David Wiley proposed an alternative definition that is limited only to digital resources. He described learning object as “any digital resource that can be reused to support learning” (Wiley, 2000).

Saum (2007) lists various alternative terms used in addition to learning objects. These include: educational objects, media objects, knowledge objects, rapid learning objects, reusable learning objects, shareable courseware objects, shareable content objects, units of learning, e-learning objects, instructional objects, intelligent objects and data objects.

The second widely used term in addition to learning objects is digital learning resources.

Digital learning resources

In the educational community and teacher training, people prefer to use less technical terminology. An OECD study on digital learning resources (OECD, 2009) defines digital learning resource as “any digital resource that is actually used by teachers and learners for the purpose of learning”.

The same term is also preferred in the United Kingdom educational sector. A BECTA[1] report on digital learning resources understands digital learning resources as “resources designed to be used by teachers in supporting learning activities; where the resources are provided by or derived from digital products” (Sheffield Hallam University, 2008).

The same term is used also in various software applications targeted for teachers. European Schoolnet has developed a digital learning resource portal called Learning Resource Exchange (see http://lreforschools.eun.org/).

In the context of this document we will mostly use the term *digital learning resources*.

Open Educational Resources

The third term that has become widely used in recent years is open educational resources. This marks only part of digital learning resources that are available under an open license that allows reuse (and often also modification).

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[1] British Educational Computing Technology Association. It is currently being closed down by the UK government.

Open educational resources can be defined as “educational resources (lesson plans, quizzes, syllabi, instructional modules, simulations, etc.) that are freely available for use, reuse, adaptation, and sharing” (Gurell, 2008). This topic is discussed further in sections 1.4 and 1.9.

Other important terms

There are some other important terms that are needed in order to better understand this report. They are discussed in details in further sections.

Learning Object Metadata (LOM) is a data model used to describe a learning object. Typical attributes described in the metadata include type of object, author, terms of distribution, format and pedagogical attributes, such as teaching or interaction style.

Learning Object Repository (LOR) is a digital library used for storing the learning objects and their metadata.

1.2 Paradigm shift

The emergence of Learning Objects mark an important paradigm shift. In the mid 1990s it was common to distribute learning content on CD-ROM discs. The educational content and the navigation structure were often implemented as one complete application. This approach had several shortcomings. At first, it was difficult or impossible to extract individual learning resources from the application. Secondly, it was not possible to update the content if mistakes were found or new information appeared. Finally, the application might only work with a certain version of the operating system and would become useless when a new version of Windows was adopted.

The learning objects approach was an attempt to solve all these issues. The SCORM standard suggests that the Web is the best platform to maximize access to, and reuse of, learning content (ADLNet, 2006). The SCORM standard also lists six abilities made possible by the learning objects approach:

- **Accessibility**: The ability to locate and access instructional components from one remote location and deliver them to many other locations.
- **Adaptability**: The ability to tailor instruction to individual and organizational needs.
- **Affordability**: The ability to increase efficiency and productivity by reducing the time and costs involved in delivering instruction.
- **Durability**: The ability to withstand technology evolution and changes without costly redesign, reconfiguration or recoding.

- **Interoperability**: The ability to take instructional components developed in one location with one platform or set of tools and use them in another location with a different platform or set of tools.
- **Reusability**: The flexibility to incorporate instructional components in multiple applications and contexts.

1.3 Historical overview - timeline

In this section we give a brief overview of the history of digital learning resources. A detailed history of learning objects has been compiled by Robert R. Saum (2007).

1992

The term learning object is first mentioned. A well-known e-learning expert Wayne Hodgins was watching one of his children playing with Lego blocks. Hodgins realized that the similar building blocks could be used for creating digital learning resources. He termed those building blocks learning objects.

1994

Working groups to study the field of learning objects were started by Computer Education Management Association and Oracle.

1996

First projects for creating learning object repositories were started. These include ARIADNE (see http://www.ariadne-eu.org/) and Gateway to Educational Materials (GEM) (see http://www.thegateway.org/). Also, the IEEE Learning Technology Standards Committee was formed.

1997

IMS Global Learning Consortium was formed. They have had an important role in the development of many learning technology specifications. Another standards-related initiative that was formed was Advanced Distributed Learning (ADL) Initiative that is behind the SCORM standard. Learning object repositories that were opened include MERLOT (see http://www.merlot.org/) and GEM.

1998

The first draft version of IEEE Learning Object Metadata standard was published. This year marks also the first steps towards open educational resources. The first version of Open Content License was published.

1999

First open educational resources projects were established. These include MIT OpenCourseWare (see http://ocw.mit.edu) and Connexions (see http://cnx.org/).

2000

The first version of SCORM is released.

2002

IEEE Learning Object Metadata becomes an official standard. Also, the first set of Creative Commons licenses is released. Later versions of Creative Commons licenses are currently the most commonly used licenses for digital learning resources. The term "open educational resources" was first adopted at UNESCO's Forum on the Impact of Open Courseware for Higher Education in Developing Countries.

2004

SCORM 2004 standard is released. It defines the communication between client side content and a run-time environment, which is commonly supported by a learning management system.

1.4 Recent trends

The most important trends in recent years include open educational resources, user generated content and use of Web 2.0 tools.

Open educational resources

Open educational resources are educational materials and resources offered freely and openly for anyone to use and under some licenses to remix, improve and redistribute. These resources include (1) learning content (complete courses, content modules, learning objects, media files), (2) tools (software for creating open educational resources, learning management systems, etc) and (3) implementation resources (licenses, design principles, localization principles).

Important repositories and collections of open educational resources include:

- OER Commons (see http://www.oercommons.org/)
- MIT OpenCourseWare (see http://ocw.mit.edu/)
- Connexions (see http://cnx.org/)
- WikiEducator (see http://wikieducator.org/)
- Curriki (see http://www.curriki.org/)
- Wikiversity (see http://www.wikiversity.org/)

- LeMill (see http://lemill.net/)

Open educational resources are typically published under one of the Creative Commons licenses. These licenses are discussed in details in section 1.8.

User generated content

The availability of simple authoring tools has made it possible for any educator to create and publish their own digital learning resources. These tools include multimedia software that comes with any computer (Windows Movie Maker, iLife), free learning content authoring tools (eXe Learning) and various online environments.

Towards the end of the 1990s and beginning of 2000s it was common that learning resource repositories were pre-moderated. The quality of learning resources was evaluated, and their metadata was then enriched by experts. The learning resources were published only after that procedure. Nowadays it is more common for learning resources to be published immediately after being uploaded by the author.

Several learning resource platforms have taken a collaborative authoring approach. This means any registered user (in some cases also anonymous users) can edit and improve content published by other users. Repositories that have taken this approach include LeMill and wiki-based initiatives (Wikiversity, WikiEducator, Curriki).

User generated content leads to issues with the quality of learning resources. In some cases, this issue has been solved by a large and active user community, but many open educational resources platforms have not yet reached a critical mass of users.

Use of Web 2.0 environments

Another trend related to user generated content is the use of Web 2.0 tools. Typically these are generic tools that are not specifically made for publishing educational content. However, these tools can be used together with specific learning resource authoring tools. Some common examples of Web 2.0 tools used for creating digital learning resources include movie sharing platforms (YouTube, http://www.youtube.com/) and presentation sharing communities (SlideShare, http://www.slideshare.net/). Movies and presentations can be connected with the learning resources using a technology called *embedding*. As a result, the movie or presentation is displayed as an organic part of the learning resource.

Social recommendation of learning resources

Empirical studies have shown that authors complete only a small subset of metadata fields that are requested during the publishing process (Najjar & Duval, 2006). In recent years more lightweight approaches to learning resource metadata have appeared. One example of this is social tagging that is a common practice in many Web 2.0 environments. Social tagging means that authors (and often also other users) can add freely selected keywords to describe the learning resources. This practice is used in LRE Portal, OER Commons and LeMill.

Repository networks and federated search

Various learning object repositories were developed towards the end of the 1990s and beginning of 2000s. However, at that time the aim of learning object repositories was not only sharing learning resources, but also protecting the learning resources from being accessed by unauthorized users. In recent years education has started to move towards openness and the repositories have started to find ways to make their resources more easily accessible. One development in this area includes repository networks and federated search. The main idea is that the metadata of learning resources is made accessible or replicated to other repositories. This means that users can use one search form for finding learning resources from multiple repositories around the world. This kind of repository include Globe (see http://www.globe-info.org/), LRE Portal and several others.

1.5 Types of digital learning resources

The main types of digital learning resources have been specified by the metadata standards. IEEE Learning Object Metadata standard suggests the following vocabulary for learning resource types:

- exercise
- simulation
- questionnaire
- diagram
- figure
- graph
- index
- slide
- table
- narrative
- text
- exam

- experiment
- problem
- statement
- self
- assessment
- lecture

The IEEE Learning Object Metadata standard does not, however, include further explanations on these learning resource types.

A more up to date list of learning resource types is defined in the Learning Resource Exchange Metadata Application Profile developed by the European Schoolnet. Their metadata application profile extends the IEEE LOM standard with several learning resource types that are common in the era of Web 2.0. Also, they provide explanations and/or examples for each learning resource type. LRE Metadata Application Profile makes a distinction between the learning resources and learning assets. Types of learning resources include:

- application
- assessment
- broadcast
- case study
- course
- demonstration
- drill and practice
- educational game
- enquiry-oriented activity
- experiment
- exploration
- glossary
- guide (advice sheets)
- lesson plan
- open activity
- presentation
- project
- reference
- role play

- simulation
- tool
- web resource (weblog, website, wiki, other web resource)
- other

Types of learning assets include:

- audio
- data
- image
- text
- video

In addition to these commonly agreed learning resource types there are several alternative learning resource types that are proposed by educational technology researchers. One such type is PILOT - progressive inquiry learning object template (Põldoja et al, 2006).

1.6 Standardization of Digital Learning Resources

The aim of standardization is to support the interoperability, portability and reusability of digital learning resources. Interoperability is the ability of two or more systems or components to exchange information and to use the information that has been exchanged.

Standardization became an issue when the first learning object repositories were built. In order to make learning resources easy to find they had to be described with the proper metadata. The most suitable metadata set that was available at that time was Dublin Core (see http://dublincore.org/). However, the Dublin Core Metadata Element Set contained only elements that were useful for describing generic resources (books, digital resources). This was not enough for digital learning resources, which would also have detailed educational and technical characteristics.

IEEE Learning Object Metadata standard (IEEE LOM) was developed as a joint effort between several initiatives under the guidance of IEEE Learning Technologies Standards Committee. The final version was completed and published in 2002 (IEEE, 2002). The IEEE LOM element set is divided into 9 categories, each of which contains sub-elements:

2. General
3. Life Cycle
4. Meta-Metadata
5. Technical
6. Educational
7. Rights
8. Relation
9. Annotation
10. Classification

Several groups have developed their local guidelines on implementing the IEEE LOM. These guidelines, known as application profiles, include UK LOM Core, CanCore, LRE Metadata Application Profile and several others.

Another important standard is the **Shareable Content Object Reference Model** (SCORM) that has been developed by the Advanced Distributed Learning (ADL) Initiative (see http://www.adlnet.gov/). SCORM is a collection of standards and specifications that define communications between client side content and a host system called the run-time environment. SCORM content is typically packaged into a transferable ZIP file that is used in a learning management system. The most current version of the standard (SCORM 2004, 4th Edition) was published in 2009. However, SCORM is less widely adopted than IEEE LOM and only part of the content authoring and delivery tools are SCORM compliant.

Digital learning resources may be also used for testing and assessment. This area is regulated by the **IMS Question and Test Interoperability specification** (IMS QTI) that defines a standard format for the representation of assessment content and results (see http://www.imsglobal.org/question/).

New content packaging specification: IMS Common Cartridge[2]

According to the IMS website, the Common Cartridge defines a new package interchange format for learning content, able to run on any compliant LMS platform. Version 1.0 supports the following features:

- Rich content
    - html, xml
    - web links
    - media files (e.g., mpg, jpg, mp3)
    - application files (e.g., Microsoft Office)
- Integrated assessments
    - Multiple choice (single or multiple response)
    - True/false
    - Essay
    - Simple ‘fill in the blank’
    - Pattern match

1. Discussion forums
2. Metadata – both descriptive metadata for cartridges and roles-based for resources
3. Authorization for protected content

Future versions will introduce:

- Web/enterprise integration with third-party tools and services
- Lesson plans
- Competency maps based on educational standards
- Accessibility support

Creating the Common Cartridge

Common Cartridge v1.0 is already available, along with a test tool for testing cartridges for conformance with the specification. The project group, made up of major publishers, LMS vendors, the open source community, and other interested parties, is now working on CCv1.1 which will add some exciting new features, such as seemless integration with web applications and eBooks using LTI. The CC & LTI Alliance provides a number of resources to help software vendors implementing the specification, content providers creating cartridges and user institutions and practitioners in harnessing the power of Common Cartridge.

[2] http://www.imsglobal.org/commoncartridge.html

The Common Cartridge builds upon the widely implemented IMS Content Packaging specification, adding support for the following standards:

- Metadata
  - ISO 15836:2003: Dublin Core Metadata Element Set (mapped to the corresponding elements in LOM)
  - IEEE 1484.12.1-2002: Learning Object Metadata
  - IEEE 1484.12.3-2005: LOM Schema binding (loose binding)
- Content
  - IMS Content Packaging v1.2
  - IMS Question & Test Interoperability v1.2.1

IMS Authorization Web Service v1.0

Emerging standard for course metadata: XRCI

The aim of XRCI, according to JISC (2003)[3] is to define a vocabulary and appropriate technology bindings (e.g. XML, RDF) for describing course- related information that encompasses course marketing, course quality assurance, enrolment and reporting requirements. This work may be of future interest in helping S-TEAM develop better ways of adding metadata to its content resources.

1.7 Authoring of Digital Learning Resources

Digital learning resources can be created using various tools. Here we will describe some of the common approaches.

Generic multimedia authoring tools

In many cases digital learning resources are created by using generic multimedia authoring tools. This includes authoring environments such as Adobe Flash, sound and movie editing software, etc. Both professional and consumer software may be used for creating digital content. However, these applications typically do not support learning technology standards. Therefore it is not possible to embed the metadata with the content. Also, it may be complicated to reuse resources created in this manner. As this is an emerging field, with rapidly-evolving open-source technologies, we do not have a definitive solution at this time, but future version of this report will revisit the issue.

Learning content authoring tools

Learning content authoring tools are applications that are created specifically for authoring learning content. These applications are typically specialized on SCORM-compliant content packages that can be described with required metadata and reused in learning management systems. There are both

[3] See: http://www.pesc.org/library/docs/workgroups/course%20catalog%20workgroup/XCRIprojectplan.pdf

commercial and free applications available. Well-known free applications include eXe Learning (see http://exelearning.org/) and CourseLab (see http://www.courselab.com/).

Question and test authoring tools

A separate category of applications is designed for creating questions and tests following the IMS QTI specification. This includes both desktop software (such as Hot Potatoes, see http://hotpot.uvic.ca/) and web-based environments.

Authoring online courses

Ossible software applications include:

Open-source LMS: e.g. Moodle[4]

Commercial LMS: e.g. BlackBoard[5]/WebCT, Fronter[6]

Online environments for creating digital learning resources

As a lot of software applications are moving to web there have been also attempts create web-based tools for authoring digital learning resources. These tools attempt to combine the Web 2.0 and user generated content approach with support for learning technology standards. Some note-worthy applications include Connexions and LeMill.

Generic Web 2.0 applications

Web 2.0 applications are becoming increasingly popular among teachers who want to create and share digital learning resources. However, these applications have the same shortcomings as generic multimedia authoring tools. Typically these applications support only a few metadata elements that are not enough for describing the learning resources. On a positive side, Web 2.0 environments support technologies such as embedding that allows to combine content from Web 2.0 services with digital learning resources.

We suggest that a good authoring approach can combine these various tools. Digital media can be produced using generic multimedia applications and published in Web 2.0 services. Learning resources can be created using special online environments that support learning technology standards and embedding from Web 2.0 services. For questions and tests, specialized applications are the best choice.

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[4] See: http://moodle.org/

[5] See: www.blackboard.com

[6] See: http://com.fronter.info/

1.8 Learning Object Repositories

A learning object repository is a digital library that stores learning resources and their associated metadata records. These systems enable educators to manage, share, find and reuse educational resources.

Modern learning resource repositories are built as web services that exchange data with other systems (learning management systems, other repositories, search interfaces, publishing interfaces). Data storage and exchange is facilitated by various standard such as IEEE LOM, and its application profiles.

It is common that repositories have a search interface that is targeted for end-users. This interface allows users to submit simple and advanced search queries. Also, it is possible to browse learning resources by various criteria. Each resource has a detailed information page that contains the available metadata and a link to view or download the resource. In some cases the access to resources may be restricted.

Learning object repositories have often also a publishing interface. It is common that access to this interface is limited and only authenticated users can publish their learning resources. Also it is common, that resources are held for moderation before they are published.

A special type of repository is called a ‘meta-repository’ or ‘referatory’. These systems include only the metadata of digital learning resources. Resources itself are stored in other repositories or elsewhere in the web.

1.9 Digital Learning Resources and Copyright

The reuse of digital learning resources is often hindered by the copyright laws. In order to translate or modify the resource the user must have an agreement from the copyright holder (an author or publisher). This process could be simplified if the author gives some of the rights to the users. This can be done by using open content licenses. Learning resources published under these licenses are known as open educational resources.

The most widely used open content licenses are Creative Commons licenses (see http://creativecommons.org/). This is a family of six licenses that contain various levels of restrictions:

- Attribution license
- Attribution-No Derivative Works license
- Attribution-Noncommercial-No Derivative Works license

- Attribution-Noncommercial license
- Attribution-Noncommercial-Share Alike license
- Attribution-Share Alike license

Every Creative Commons license allows users to copy, distribute and transmit the work. Licenses that do not have *No Derivative Works* restriction also allow users to adapt the work.

Every Creative Commons license requires that the original work should be attributed in the manner specified by the author or licensor. *Share Alike* restriction means that the modified work may be distributed only under the same or similar license. *Noncommercial restriction* does not allow the use of the work for commercial purposes. The most limiting restriction is *No Derivative Works* that does not allow modification of the work.

An Important issue with Creative Commons and other open content licenses is license compatibility. In many cases it is not permissible to combine content that has been published under different licenses. Therefore it is important to choose a license that is compatible with the majority of other openly licensed content in the field. The Attribution-Share Alike license that is used in Wikipedia and several open educational resources projects is becoming a justified choice.

1.10 Promoting Digital Learning Resources

In this section we will discuss some of the methods used to promote digital learning resources.

If information about digital learning resources is stored only in a certain repository, its target group will be limited to the users of that repository. To make learning resources accessible at the global scale, many of the repositories have implemented technologies for metadata exchange. This is typically based on the *Open Archives Initiative Protocol for Metadata Harvesting* (OAI-PMH). Metadata from local repositories is harvested to meta-repositories or referatories. Some repositories that collect content through harvesting include Learning Resource Exchange and OER Commons.

Another approach to promote digital learning resources is based on recommender systems. These are commonly used in many Web 2.0 applications. Typically, a recommender system compares a user profile to some reference characteristics, and seeks to predict if the item is valuable for the user. A common example is the recommendation algorithm that is implemented in the Amazon online store (people who buy x also buy y). In the context of digital learning resources these recommendations are based on bookmarking, tagging and reuse. To make use of social recommendations, the metadata of learning resources should be made available in a repository that supports these technologies. Bookmarking and tagging are supported both in Learning Resource Exchange and OER Commons.

Learning resources can be promoted also by supporting common Web 2.0 technologies such as embedding. For example multimedia content (videos, etc) should be made available in a format that allows any web user to embed it into external web sites. Embedded resources typically draw much more attention than linked resources.

Social networking and tagging sites such as Facebook, Like, Digg, Del.icio.us, and Really Simple Syndication (RSS), as available e.g. in LeMill, are examples of relevant technologies in this field.

1.11 Using and Re-using Digital Learning Resources

There are several scenarios concerning how digital learning resources may be used. The type of use is typically influenced by the technical implementation of the learning resource.

The simplest way of enabling the use of a digital learning resource is by providing a link to the resource. The learning resource has to be made public on the web. Technically the resource may be either a web-based resource or a file that can be downloaded.

If the learning resources have been created according to the SCORM standard they can be imported to the learning management systems that support SCORM content packages. In this case it is possible to track how the learner is using the resource, save the status of the system when the learner is making a break and store the test scores.

Together with use, it is also important to think about reuse of digital learning resources. In some cases the teachers need to adapt the learning resources to their students‘ needs. This must be supported both by the technical implementation and the license. Some of the learning resource authoring platforms (such as LeMill) are built in a way that allows other users to modify and improve the resources.

2. Good practice

2.1. Analysis of previous projects

There have been several projects under different EU funded programmes, that have focused on building a learning resource exchange in schools, development of learning objects (LO) or the meta-data of LOs. The most relevant practices for S-TEAM's study could be Celebrate (2002-2004), Calibrate (2005 - 2008), MELT (2006 - 2009), ASPECT (2008 - 2011), Xperimania (2007 - 2008), Scientix (2009 - 2012) and iCoper (2008-2011). Relevant practices can be divided into projects focused on delivery systems (Celebrate, Scientix), meta-data and standardization development (iCoper, Melt, ASPECT), and development and creation of LOs (Calibrate, Celebrate, Xperimania). Some of the projects had general goals and science education context was not primary, whilst on the other hand, projects like Xperimania and Scientix focused only on the science education domain.

2.1.1 Celebrate

Provider, aim and type

Context *e*Learning with Broadband Technologies (CELEBRATE) was a large-scale 30-month demonstration project (June 2002 – November 2004) co-ordinated by European Schoolnet and supported by the European Commission's Information Society Technologies Programme (IST). Learning objects and simple LO authoring tools were developed by project partners and made available via a password protected web site (Demonstration Portal).

Target group

CELEBRATE was designed to address all parts of the educational content value chain and involved 23 participants from the public and private sectors including Ministries of Education, universities, leading educational publishers, content developers, VLE vendors and technology suppliers from 11 countries.

Quantity of LOs (including scientific materials)

CELEBRATE did not attempt to develop LOs in all subjects but tried to achieve critical mass in a small set of subjects (Mathematics, Science, Art, and Languages). During the project, 657 LOs (total amount was 1350 LOs developed within project) were developed in the field of natural sciences, 325 in physics, 210 mathematics, 162 biology, 105 environmental education and 80 in the field of chemistry. Content was tested in 319 schools in six countries.

Licenses

During the project, licenses were not emphasized, but in the evaluation phase it was clear that licenses should be focused and therefore there is need for open content.

Languages

Portal interface in six languages, LOs in 8 languages.

Technological solution

Digital learning resources environment (DLE) Celebrate's Demonstration Portal included a large number of Learning Assets (images, audio files etc.). These were provided mainly to assist those teachers who wanted to create their own LOs using the authoring templates. The CELEBRATE portal and brokerage system represents an important new version of such a closed system, in which a number of different providers can make their LOs jointly available to schools through this shared channel as well as, in many cases, through their own repositories and often within their own VLEs. The Demonstration Portal itself consists of a number of sub-systems that were developed and implemented during the project including the Learning Management System (LMS). The Demonstration Portal can be found at http://demoportal.eun.org and is a:

- **Virtual place** where end-users were introduced to Learning Objects, Learning Assets, Learning Management Systems, Authoring Tools (users can work with templates in this area; for example, a 'crossword' template can be used to construct a crossword as a closed activity that requires students to fill in a missing word or phrase. Other templates include multiple-choice questions, slide shows that present sequences of images (Learning Assets) etc.), and other aspects of the Demonstration Portal functionality.
- **Virtual platform** to experiment and test LOs and the tools provided by the system
- **Full system** where the user could:
- **search; browse**, **inspect** a list of the resulting LOs;
- **evaluate** LOs; **retain** any required;
- **download** or **use** directly from the Portal; or **save** them to the Virtual Classroom (this provides a way for teachers to create and manage an electronic environment for students to participate in a learning experience),
- **Create**/**Contribute** - add a learning resource*:* this is used to upload LOs created by any system user to the Portal repository,
- **evaluate** a LO,

- **Get** a**dvice**: this provides teachers with pedagogical suggestions and guidelines for the use of LOs, project questions and answers, glossary of terms useful links, the technical specification for LOs, and the CELEBRATE metadata;
- c**ommunity**: this provides a discussion forum where teachers can share ideas, comments, and experiences with other teachers of their own country, as well as ask questions, find colleagues online and seek partners for collaborative projects.

Lessons from Celebrate:

- Instability of the system during the early stages of the project influenced the teacher confidence and caused teachers to avoid using the technology in future lessons;
- Within LOs, there should be some instructions on how LOs should be used in different types of classroom activities;
- Celebrate demonstrated well the concept of learning resources environment, but connecting to a federation of repositories required effort and commitment;
- Licensing mechanism needs to allow for open content;
- Educational budgets struggle to cope with the demand for more/better metadata created by trained indexers;
- It is more useful to think of LOs having “affordances” or lending themselves to a particularly pedagogical method or learning style;
- Need for metadata that more accurately reflects how LOs are actually used in different learning contexts;
- Social tagging by teachers should be more focused

2.1.2 Calibrate

Provider, aim and type

CALIBRATE (Calibrating eLearning in Schools) was a 30-month project (October 2005 – March 2008) co-ordinated by European Schoolnet (EUN) and supported by the European Commission's Information Society Technologies Programme (IST). Project focused on LOs (their collaborative use and exchange in schools), and on federated searching of learning repositories supported by six Ministries of Education (Austria, Estonia, Hungary, Lithuania, Poland and Slovenia).

Target group

Education authorities, teachers, trainee teachers

Quantity of LOs (including scientific materials)

CALIBRATE partners have provided the LRE with more than 200,000 resources/assets from 25 content providers, including 28 Ministries of Education: Austria, Belgium (Flemish-speaking community), Catalonia (Spain), Czech Republic, Estonia, Finland, France, Hungary, Germany, Iceland, Israel, Ireland, Italy, Lithuania, Norway, Poland, Portugal, Slovenia, Spain, Sweden.

Licences

Ministries and other public sector partners contributing resources to the LRE are making their content available under Creative Commons' licenses. Individual teachers, who have authored content using LeMill and other open source tools, are required to add a CC license before material is 'published**'.**

Languages

LOs in more than 20 languages

Technological solution

Organizations can connect to the LRE federation in a matter of days rather and LRE users could exploit new personalized and curriculum search features. In addition, the LeMill learning toolbox was developed in the CALIBRATE project and which is specifically described in section 2.2.2.

Lessons from Calibrate:

- Provide adequate technical and pedagogical support and training for teachers
- Produce LOs that can become catalysts for pedagogical change
- Mind the usability
- Create support for the use of a LO

- Design flexible LOs

2.1.3 MELT

Provider, aim and type

The MELT (Metadata Ecology for Learning and Teaching) ‘content enrichment’ project (eContent*plus* Programme) coordinated by EUN brings together a critical mass of existing educational ‘open content’ from 17 public and private sector partners including 12 Ministries of Education and regional education authorities. **The** MELT project was needed because the federation of repositories are of little use if there is still an existing problem of high-volume metadata creation. MELT provides harvesting, enrichment of the content, metadata generation and validation services.

Target group

The stakeholders and primary end-users in the MELT project are schools. The project was designed to both raise the awareness of teachers the need for accurate tagging of resources and to provide a user-friendly system that motivates teachers to quickly and easily add metadata to resources that they have both used and created.

Quantity of LOs (including scientific materials)

Within the project, more than 150 000 open learning resources for all ages and subjects for schools were enriched through social tagging by experienced indexers as well as end-users.

Licenses

More than 71.5 percent of all resources were licensed under the Creative Commons license. Of these, 100 percent contained the license “attribution” and 75 percent the license type “non commercial”. 28.5 percent of the resources did not contain a Creative Commons license but had another type of open license.

Languages

The MELT portal has a user interface that supports 23 languages and also cross-translation of LOs metadata.

Technological solution

Project's provide a new metadata-ecology involves expert indexers, automatic metadata generation and folksonomies and social tagging.

Lessons from MELT

- Teachers worked intensively with each other during face-to-face meetings. In between meetings, it was difficult to keep teachers motivated and to maintain contacts between teachers in different countries. It is possible that the older generation of teachers prefers other ways of communication to those used by new and younger teachers. Once back home, it is easy for teachers to forget ideas presented by their colleagues and more difficult to find time for sharing their experiences and to provide feedback on their use of learning objects. International collaboration over the Internet is difficult to maintain if it is not rooted in collaboration and activities at the local level. Once this is established, teachers will be more inclined to continue the work at international level.
- Sharing learning objects with international colleagues is not usually the first thing that teachers want to do. Often, what they first require is to find an interesting idea. They then look behind the ideas provided by other teachers and transform these into scenarios that work in their own learning environments. They want to be inspired by others.
- Tags are not yet used by teachers for searching for learning resources, but this is not a final conclusion – there is a need to reassess the effectiveness of tags for searching as improvements are made to how one can combine and display tags on the portal
- Although the Creative Commons (CC) licensing scheme has rapidly been adopted by many public content provider organizations, it has some limitations, particularly regarding content from commercial providers. In this regard, MELT project partners who resolved IPR issues at the beginning of the project, (i.e. when the audit of the content took place) were able to plan their enrichment and translation work better since they have a more precise estimation of the learning objects that would eventually be made available in the MELT federation.

2.1.4 Xperimania

Provider, aim and type

The Xperimania project was organised by the Association of Petrochemicals Producers in Europe (APPE), and coordinated by European Schoolnet on their behalf during 2007-2008, continued partially into 2009. All schools in the European Union, candidate countries and EFTA countries were invited to join with the project. The aim was to help students in lower and secondary school classes (covering pupils aged 10-20) and their teachers to understand the wide variety of applications of physics and petrochemistry and how this relatively new science has contributed to the evolution of many day-to-day items. The project's goal is to combat students' bad perceptions of chemistry by offering simple hands-on activities to help teachers revitalize their teaching, and to raise awareness of petrochemistry among secondary school students.

Target group

Project focused on students and teachers who are interested in development of digital scientific learning resources.

Quantity of LOs (including scientific materials)

Altogether 447 scientific submissions were uploaded to the project's website during the project.

Licenses

No focus on licenses

Languages

Portal have been translated into thirteen languages, no information about the language about learning resources.

Technological solution

All students were invited to upload their lab report (in pdf format) and other files (picture in jpg format, PowerPoint presentation or video file converted to swf format) on the official competition website. All the submissions of the competition were displayed, and they are still visible in an online gallery. Students had a chance to choose between two different categories in which to participate:

Timeline Competition: Teachers and students were invited to explore a scientific discovery in the field of materials from 1800 to the present day. They needed to produce a digital resource describing what they have found out about the discovery. The entry had to include a short text and a picture. They could also make a film, audio file, visual resources or text-based document to illustrate their work. Once uploaded to the website the entry became part of an interactive timeline of discoveries in materials.

Experiment Competition: Teachers and students were invited to set up an easy and fun experiment in science to investigate the properties of materials. The lab report then had to be uploaded together with a video, or photographs on the website. All the submissions of the competition were displayed in an online gallery. In the experimental part of the project, participation of teams of maximum 3 students was expected.

Lessons from Xperimania:

- Digital learning resources do not have to be authored exclusively by teachers; students can develop high-quality learning resources if provided with suitable guidance
- Limiting the format of digital learning resources to closed, proprietary formats (in Xperimania's case: ppt, pdf and swf) could result in threats to re-usability and durability of the resources.

2.1.5 ASPECT

Provider, aim and type

ASPECT is a 30-month, Best Practice Network (BPN) supported by the European Commission's eContent*plus* programme and coordinated by European Schoolnet (EUN), that involves 22 partners from 15 countries, including 9 Ministries of Education (MoE), four commercial content developers and leading technology providers. Commercial content developers are Siveco Romania SA, Cambridge University Press Ltd, Young Digital Planet SA and Fodeon. The project aims to improve the adoption of learning technology standards and specifications. ASPECT is exploring two categories of specifications: specifications for content use (e.g., content packaging formats, access control, and licensing); and specifications for content discovery (e.g., metadata, vocabularies, protocols, and registries). The aim is to: assess standards and specifications through their implementation on a critical mass of educational content; to develop best practice in terms of implementing those standards; make recommendations on the combination of a number of standards to ensure more transparent interoperability.

Target group

Educators will have an easy way to discover learning content; students benefit from having access to learning resources; content providers will be able to make their products interoperable and to promote/market them; system vendors will only need to support a limited set of specifications to make their systems compliant with learning resources from major federations; repository and federation builders will secure and maximise their investment by developing infrastructures based on standard specifications.

Amount of LOs (including scientific materials)

A critical mass on content has been brought together from earlier projects (such as CALIBRATE and MELT). As the project is still running, the exact number of LOs is diffcult to estimate, but the LRE federates more than 30 repositories, thereby providing access to more than 200,000 learning resources and assets and their metadata.

Licenses

Creative commons, IMS Common Cartridge, LRE DRM

Languages

Materials are provided in different languages, by using automatic translation service - ASPECT Vocabulary Bank

Technological solution

To assist stakeholders involved in applying standards and specifications for learning technologies, ASPECT is providing a new set of tools and support services that will facilitate the interoperability of learning content. The project will also launch a Service Centre that provides the following services: Identity service (based on the handle), Metadata translation service, Metadata transformation service, Metadata validation service, Vocabulary Bank for Education, Learning Object Repository registry (early prototype), Harvesting back service.

Lessons from ASPECT

Project is still running and therefore only first phase evaluation has been made, but so far following issues should be considered:

- More support materials (web-based information and a tutorial) should be developed and tested with content providers
- Closer coordination of technology providers and content providers to increase the understanding of the standards deployment process.
- Pay special attention to content providers’ understanding of standards and their benefits to their organisation; engagement in OER initiatives
- Close monitoring of the progress of the content providers. We suggest implementing a (virtual) 'help desk' for content providers to assist with LRE connections as well as content packaging. This could guide and provide answers when content providers have questions and difficulties regarding standards implementation, compliance testing and conversion processes.
- Provide realistic tutorials and visual representations (such as screenshots and screen captures) for the most important tools.
- Extend the current collection of best practices, providing more concrete real world examples and hands-on experience during workshops
- Testing interoperability with teachers should involve testing CC packages with learning management systems (will depend on the availability of CC compliant platforms, such as Moodle) and/or social networking tools (web 2.0 tools such as blogs, wikis, Facebook accounts,

etc.) that the teachers already use in their work. The starting point would be to make the setting as familiar as possible to ensure that the packaging function is the only new aspect of the setting that the teachers will face.

- Communication and collaboration between technology and content providers is a critical success factor and needs special attention.
- Standards and specifications are not always understood and are perceived in very subjective ways. It is highly necessary to show the benefits of standards and specifications through very practical examples.

2.1.6 iCoper

Provider, aim and type

ICOPER is a Best Practice Network co-funded by the eContentplus programme of the European Community. The 30-month project started in September 2008 and has a mission to collect and develop further best practices for the design, development and delivery of interoperable content which supports competency-driven higher education.

Target group

Technology suppliers (publishers, vendors, integrators, tool developers), management and policy makers, standardization experts (researchers, domain experts), learning professionals using or developing learning material (teachers, learners), University support centres and instructional designers (advanced end users and researchers, advanced learners), curriculum developers (study programme committees).

Quantity of LOs (including scientific materials)

ICOPER will provide access to a critical mass of more than 12 500 hours of integrated educational content. At the moment, 9 repositories have added their materials to Open iCoper Content space and in total, more than 50 000 LOs are presented.

Licenses

Materials are expected to be developed under CC license.

Languages

Materials can be found in 23 different languages.

Technological solution

iCoper project develops many services, including:

- **repository services** (search and retrieval of sharable educational resources by type using metadata, metadata harvesting),
- **publication services** (management of collections of learning resources),
- **recommendation service** (list users whose learning outcome profile contain a given learning outcome, advise user of missing LO to obtain a degree),
- **learning registry services** (provide a catalogue of Learning Objects Repository (LOR) with corresponding transfer protocols),
- l**earning delivery services** (searching /retrieving UoL or LO, importing/exporting UoL or LO, and authentication),
- **validation services.**

2.1.7 Scientix

Provider, aim and type

Scientix is managed by European Schoolnet (EUN) on behalf of the European Commission, project started in December 2009 and the website (http://www.scientix.eu) was launched in May 2010**.** The Scientix portal collects and then provides teaching materials and research reports from European science education projects financed by the European Union.

Target group

Scientix is open for teachers, students, researchers, policy makers

Amount of LOs (including scientific materials)

At the moment (October 2010) a total of 70 learning materials and project reports related to science education have been linked via Scientix.

Licenses

No information about licences used. As the system includes embedded materials collected from different repositories, then each material has a previously defined license. In many cases, there is no reference to the original author of an embedded Java applet, nor to the license.

Languages

Includes translation on-demand function. The metadata of learning resources is multilingual, translations are available in multiple languages. Additional translations of metadata can be requested into the 23 official languages of the European Union. Portal is available in six languages: English, French, German, Spanish, Italian and Polish.

Technological solution

The web site of Scientix (http://www.scientix.eu) is based on the platform developed for Learning Resource Exchange.

In order to access materials, users do not have to be logged-in. Users can't add materials, as system automatically collects scientific learning resources from different repositories.

Lessons learned from Scientix:

- It is important to provide simple tools and guidelines for localisation of learning object metadata
- If possible, interactive components of digital learning resources should be developed so that they are language independent and embeddable to Wikis, blogs, web pages. It is much easier to translate the HTML "wrapper" where an interactive applet is embbeded, than the applet itself.
- An indication of license (All Rights Reserved, Creative Commons or Public Domain) and the references to original authors should be made clearly visible on the front page of the resource, but also added to metadata. This would allow searching of resources which can be edited or localised wihtout threats of violating Intellectual Property Rights.

2.2. Existing DLEs in science education domain

2.2.1 LeMill

LeMill (http://lemill.net) is based on open source software, has established a stable user base in both Estonia and Georgia and built up an active global community of LeMill users. Important new research in the project has also advanced the state-of-the-art related to semantic interoperability of curricula descriptions of learning resources and new personalised search approaches based on agent technology. LeMill is a web community for finding, authoring and sharing learning resources. Users can find learning resources and use the resources in teaching or learning. Users can also add their own learning content to LeMill. Users may edit their own content and combine larger chunks of learning resources from individual media segments. If users wish they may also join some of the groups producing or editing learning resources. In LeMill the content is always easily found where and whenever they are needed.

2.2.2 Learning Resource Exchange (LRE)

Learning Resource Exchange (http://lreforschools.eun.org/LRE-Portal/Index.iface) for schools was officially launched in December 2008. It has more than 200 000 learning resources/assets from more than 25 providers. The portal has been promoted initially to 60 0 000 eTwinning schools. The LRE is a service for Ministries of Education, driven by Ministries of Education and also involves private sector partners. The main aim is to improve use and reuse of educational content in schools (better technical interoperability between repositories, improve semantic interoperability of content, develop best practice in how to implement content-related standards. LRE is not a centralised portal, but is, rather, a framework that supports semantic and technical interoperability of content repositories. The technological solution of LRE is developed so that users (organizations) can easily connect to a repository, portal or virtual learning environment in the federation. The LRE then harvests the metadata and for uploading the metadata only, an excel spreadsheet should be completed.

2.2.3 HarvestRoad Hive

HarvestRoad Hive is a digital repository, integrated with authoring and delivery solutions. Hive federates and interoperates with other repositories using open standards for data exchange. HarvestRoad Hive is suited for content delivery to large communities of users, whether within one organization or dispersed around the world. The product line includes integration with leading Learning Management Systems, such as Moodle, Blackboard and Sakai, which allow content to be delivered from the repository directly into the learning experience. These features enable Hive to underpin independent delivery of learning content while at the same time giving the organization an enterprise-ready repository for all of its content.

2.2.4 Open ICOPER Content Space

The Open ICOPER Content Space (OICS) has been defined as the umbrella combining a set of specialized interconnected repositories, content and tools, as a test bed for the specifications and standards that become part of the ICOPER Reference Model (IRM). The OICS has been conceived as a learning object repository capable of storing both learning resources and metadata records, with sophisticated services for publication, enrichment, search and retrieval. Additionally, the OICS provides services for the management of learning outcome profiles.

Learning object repository is used for storing metadata harvested from the ICOPER content providers. Metadata is synchronized between them through the SPI protocol. These services have been documented in the form of the OICS Middle layer API and have been integrated into a variety of environments (authoring environments, learning management systems, social networks and widget platforms).

2.3 Success factors

Project	**Success factors**
Celebrate	• Low cost at the point of use • Stability and technical reliability • Cultural quality of resources • Social and physical safety of resources • Motivational relevance to students • Curriculum relevance • Speed of access • Easy to use interface • Easily combined with other resources • Range of resources available • Use of a range of sensory modes • Modifiability by teachers for individual students and classes. • Given suitable pre-conditions and working methods, learning objects can be created, translated, distributed, and presented • Providing reliable and stable systems or ICT equipment is an essential condition for effective training sessions • Students collaborated in a meaningful and natural way, even though they carried out individual tasks. They helped each other and shared expertise, by showing drafts to each other or by discussing virtually.
Calibrate	• ·Guidelines of the users • Good quality of the learning material • High-level visualisation (animation, simulation, film strips, special audio files

	etc.) • Interactive, customisable learning environments (like online exercises and tests) • Innovative methodological content with little text (easy to translate or possibly even omit and replace by oral explanation). • Materials for multicultural education: short texts with extensive visuals about the culture, history, natural environment of an area that is of relevance for other countries. • PowerPoint lecture support materials about core disciplinary areas. Presentation still seems to be the most popular teaching method with ICT use. • Learning assets with international relevance: for example, images of works of famous artists or portraits of scientists, sound bytes from music belonging to the core of European cultural heritage.
Melt	• Value of looking at learning repositories beyond their borders • Satisfied with the supply of content in their own language • Place where teachers go to find ideas, not simply learning objects • National curricula and local contexts should be taken into account in order to motivate teachers and to encourage them to start working with international learning objects. • Nice, inspiring examples or scenarios, a good tool and assets to develop own learning materials, all integrated in an international community • Social tagging adds value for experienced indexers • Identified good LO which “travels well”, this type of content is typically: open, rich, surprising, innovative, language independent, attractive, appealing, free.
Xperimania	• The topic engage pupils in an inquiry-based learning approach, which was shown to have a highly positive impact on their motivation • Using the project method approach, as

	students having good multimedia skills were mixed with students who had good experimental competencies. Use of the ICT in Education combined with the project method could be a promising asset to modernize the teaching of physics and make natural sciences more attractive by engaging multimedia and Internet communication.

3. Digital learning resources development context in S-team

3.1. Types of digital learning resources developed by S-team partners

Video-based resources, DVD form or as web-based content, simulations and animations

S-team project will produce video-based materials demonstrating various aspects of inquiry based teaching in science. All video-based materials will be made available in multiple language formats (either sub-titled or with alternative soundtracks) where the material has been shown to be useful across national boundaries.

Book

S-team project produces a book with chapters drawn from across the S-TEAM work packages, in order to provide a definitive resource on Inquiry-Based Science Teaching/Education implementation for teachers and teacher educators. The book will be accompanied by a DVD with examples of good practice(s) in a variety of teaching situations.

Workbooks and guides

Training packages, course units, teacher education modules

Training packages will be available either as packs of hardcopy documentary material or as online resources, or both. It must be accessible to its target audience in terms of language and its visual or other forms of presentation.

Other types of learning materials

S-team will develop an English-language web-based resource for teachers, designed to help them understand how the changing role of the curriculum, teacher and student affects the use of ICT in the science classroom

3.2. Workflow of learning resource development in S-team project

Workflow of developing S-Team learning resources consists of following (partly overlapping) phases:

1. Analysis
2. Design
3. Development
4. Licensing
5. Storage
6. Metadata
7. Promotion
8. Pilot use
9. Adaptation
10. Localisation
11. Re-use

4. Guidelines for disseminating S-team DLEs

4.1. Metadata and standards

S-Team will make metadata of learning resources available via the Scientix portal, using the Scientix metadata profile (a subset of LRE metadata application profile). Authors of S-team learning resources are also encouraged to publish the localised version in national Learning Object Repositories.

Tagging should be implemented and used in line with **Social Tagging Services** norms. This will help: to provide links to resources; to help find related resources; to encourage participants to contribute related resources; to enable evaluation and impact analysis of the event; to encourage community building.

4.2. Storage and licensing

It is recommended to use CC licenses for all materials. If it is not possible, the alternative licence should be explicitly mentioned on the cover page of the resource. Metadata should be public also for “closed“ resources.

Digital learning resources could be stored in the following ways:

- Books in Scribd or issuu
- Learning materials in LeMill
- Video-based materials in Youtube/Vimeo
- Training modules in elgg-based environment/wikiversity, or in the Moodle instance hosted by Scientix (EUN).

Communication between science teachers in social networks

This could be implemented via the Open ICOPER Content Space, which:

a) Allows user interactions with the goal of developing a new unit of learning either:
    i. Based on existing teaching methods or units of learning or
    ii. From scratch;
b) Allows user interactions specifically intended to reuse existing units of learning.

4.3. Promotion and translation

Project Website

Social media: Flickr, YouTube, SlideShare, Issuu

Social media (likes, groups): LinkedIn (for project team), Facebook (for special interest groups).

Metadata to LRE

Embedded versions to Scientix and LeMill

S-team widget for teachers (RSS-aggregator, based on user-defined filtering criteria)

XRCI

Materials should be translated into languages of S-Team consortium members' states.

4.4 Scenarios of DLE adaptation and re-use in S-team

S-TEAM should focus on using existing environments in the development and dissemination process of digital learning resources.
The project will mainly focus on development of training courses, modules and training packages, therefor we suggest to set up an elgg-based learning environment, where all the training modules could be stored and presented as courses. It supports the national accessibility to the developed resources, which are already using different additional external Web 2.0 services like LeMill, supports collaboration between educators or other special interest groups and provides possibilities for individual learning by using weblogs. The other emphasize of the project, is the production of books, guides and workbooks that are presented as paper-based, but also electronically. For disseminating the books, the *issuu* or *scribd* environment can be used
There are also other types of digital learning resources developed during the S-Team project, for which we recommend LeMill and iCoper Open Content Space for developing and storing digital learning resources.

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S-TEAM
FIRING UP SCIENCE EDUCATION

SEVENTH FRAMEWORK PROGRAMME