CHAPTER

8

Sharing of Open Science Education Resources and Educational Practices in Europe

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Introduction

Science Education is recognised as top priority for European policy makers (Rocard et al. 2007). During the last few years, technological advancements (such as ubiquitous devices and wearable computers) and innovative applications (such as data analysis tools, simulations, augmented reality and virtual reality interfaces) have allowed the enhancement and enrichment of the current science education curricula (Rocard et al. 2007). Furthermore, a large amount of digital science education resources have become available worldwide through science museum collections and digital repositories such as Exploratorium Museum of Science (www.exploratorium.edu/), Science Museum of Minnesota (www.smm.org/) and NASA's Education Materials Finder (http://search.nasa.gov/search/edFilterSearch.jsp?empty=true), all of which aim to facilitate sharing and re-use of digital science education resources among science education communities. These resources have the potential to support technology-enhanced science education by enabling science teachers to improve their day-to-day science teaching (Rajashekar et al. 2007).

On the other hand, it has been recognised that science teachers could improve the quality of their teaching and support their motivation for enriching their teaching practices through their participation in communities of best science teaching practices, which facilitate sharing of not only digital educational resources, but also educational practices that represent their pedagogical approach. More specifically, science teachers are able through their participation in communities of teaching practices to: (a) search and download best science teaching practices for share and re-use; (b) discuss and collaborate about best science teaching practices; and (c) provide their feedback about the actual use of a science teaching practice via ratings and comments (Fu-ren et al. 2008). As a result, there is an increased interest for the development of Web-based repositories that facilitate open access to both educational resources and educational practices (Paquette et al. 2008).

In response to this increased interest for providing open access to both educational resources and educational practices among science education teacher communities, a number of prominent European initiatives have been launched. The aim of this chapter is to discuss issues related to the current trends in Web infrastructures that can support open access to educational resources and practices (namely, Learning Objects and Learning Designs Repositories) and then to present three case studies of key European initiatives in this field (the OpenScienceResources Repository, the COSMOS Repository and the PATHWAY Coordination and Support Action).

Open Educational Resources (OER) Repositories

OER can be of different granularity and different formats (Lane and McAndrew 2010). According to Geser (2007), OER should have three core features: (a) be available for open and free-of-charge access by educational institutions and end users (such as teachers and students); (b) be licensed for re-use, free from restrictions to modify, combine and repurpose, as well as be designed for easy re-use in open content standards and formats (such as SCORM, IEEE LOM and IMS LD); and (c) with regard to software tools, have a source code that is open and licensed for re-use.

Learning Objects (LOs) are a common format for developing and sharing educational content and they have been defined by Wiley (2002) as: "any type of digital resource that can be reused to support learning." More specifically, LOs include: "video and audio lectures (podcasts), references and readings, workbooks and textbooks, multimedia animations, simulations, experiments and demonstrations, as well as teachers' guides and lesson plans" (McGreal 2008). Thus, one can claim that OER are a subset of LOs that are openly licensed (Friesen 2009; Lane and McAndrew 2010).

LOs and their associated metadata are typically organised, classified and stored in Web-based repositories, which are referred to as Learning Object Repositories (LORs). McGreal (2004) has defined LORs as systems that "enable users to locate, evaluate and manage learning objects through the use of 'metadata,' namely, descriptors or tags that systematically describe many aspects of a given learning object, from its technical to its pedagogical characteristics." Most of the LORs that have been developed worldwide adopt the IEEE LOM standard (IEEE LTSC 2005) or an application profile of IEEE LOM (Smith et al. 2006) for describing their LOs, aiming to facilitate search and retrieval of them among different LORs (McGreal 2008).

Typical examples of existing LORs are summarised in Table 8.1. These LORs have been selected by considering whether they are specifically targeting science education or whether they include a considerable amount of science education LOs. For the purpose of our work, we define as a science education LO any type of digital resource that can be re-used to support science education. Note that all LORs presented in Table 8.1:

- adopt the IEEE LOM Standard or an IEEE LOM Application Profile of IEEE LOM (Sampson et al. [in press]) for describing with metadata their LOs; and
- include LOs that may target either teachers or students and this can be distinguished during searching according to the LOs metadata provided by their creators.

Table 8.1: Typical examples of existing Learning Object Repositories (LORs)

LOR name	Educational sector	Subject domain	Region coverage	Licence	No. of users	No. of total LOs [a]	No. of science education LOs	Science education LOs per total LOs
ARIADNE [b]	All sectors	Cross-disciplinary	International	Open under Creative Commons	N/A	819,177 (Large LOR)	120,993	14.76%
LRE [c]	School education	Cross-disciplinary	Regional (Europe)	Open under Creative Commons	N/A	294,429 (Large LOR)	163,734	55.61%
COSMOS [d]	School and higher education	Science education	Regional (Europe)	Open under Creative Commons	2,519	230,128 (Large LOR)	230,128	100.00%
AMSER [e]	All sectors	Science education	National (USA)	Free under Custom Licence, openness depending on the LO	N/A	134,637 (Large LOR)	134,637	100.00%
MERLOT [f]	Higher education	Cross-disciplinary	International	Open under Creative Commons	103,479	34,181 (Medium LOR)	12,491	36.54%
OER Commons [g]	All sectors	Cross-disciplinary	International	Open under Creative Commons	N/A	32,448 (Medium LOR)	17,041	52.51%
Connexions [h]	All sectors	Cross-disciplinary	International	Open under Creative Commons	N/A	21,556 (Medium LOR)	7,654	35.50%
Open Science Resources [i]	School education	Science education	Regional (Europe)	Open under Creative Commons	2,312	3,031 (Small LOR)	3,031	100.00%
ATLAS@CERN [j]	School and higher education	Science education	Regional (Europe)	Open under Creative Commons	N/A	1,740 (Small LOR)	1,740	100.00%

a Data retrieved on 10 April 2012.
b www.ariadne-eu.org/
c http://lreforschools.eun.org/
d www.cosmosportal.eu/
e http://amser.org/
f www.merlot.org/
g www.oercommons.org/
h http://cnx.org
i www.osrportal.eu/
j www.learningwithatlas-portal.eu/

As Table 8.1 shows, a considerable number of science education LOs are currently available in existing LORs; and the COSMOS Repository is currently the largest existing science education LO repository in the world. Moreover, most of these science education LOs are OER since they are openly licensed using Creative Commons (http://creativecommons.org/), which provide simple, standardised alternatives to the "all rights reserved" paradigm of traditional copyright. This provides us with evidence that LOR development for supporting the sharing and re-use of openly licensed science education LOs is an emerging trend. Nevertheless, in reality most LORs include limited explicit information about their hosted LOs' learning and educational context of use — that is, the pedagogical approach adopted, the subject domain, the intended learning outcomes and the environment within which the LOs are used (Bailey et al. 2006; Conole 2007).

It has been identified that teachers would benefit from: (a) having access to best teaching practices, (b) sharing their teaching practices with other teachers and (c) reflecting on others' teaching practices (Griffiths and Blat 2005; Conole 2008; Galley et al. 2010). This has the potential to provide learning and educational contextual knowledge of LOs available in LORs. For this purpose, there are efforts for designing and developing Web-based repositories of educational practices.

Learning Design Repositories

Learning Design (LD) is defined by Koper and Olivier (2004) as: "the description of the teaching-learning process, which follows a specific pedagogical model or practice that takes place in a unit of learning (e.g., a course, a learning activity or any other designed learning event) towards addressing specific learning objectives, for a specific target group in a specific context or subject domain." As this definition suggests, LD includes information that can contribute to the definition of learning and educational context of use for the LOs.

Similar to LOs, LDs can be organised, classified and stored in Web-based repositories, which are referred to as Learning Design Repositories (LDRs). LDRs are built so as to support storage, discovery, retrieval, use, re-use and sharing of LDs and LD Templates among educational communities (Griffiths et al. 2005; Wilson 2005). An LD Template is an LD without specific educational content (Griffiths et al. 2005). Figures 8.1 and 8.2 present an example of an LD and a corresponding LD Template.

One way of providing a standard notation language for the description of LDs and LD Templates is the IMS Learning Design Specification (IMS Global Learning Consortium 2003) and many of the existing LDRs adopt this specification for describing their LDs and LD Templates. Table 8.2 summarises key characteristics of the main existing LDRs.

Figure 8.1: A Learning Design (LD) example from the OpenScienceResources Repository.

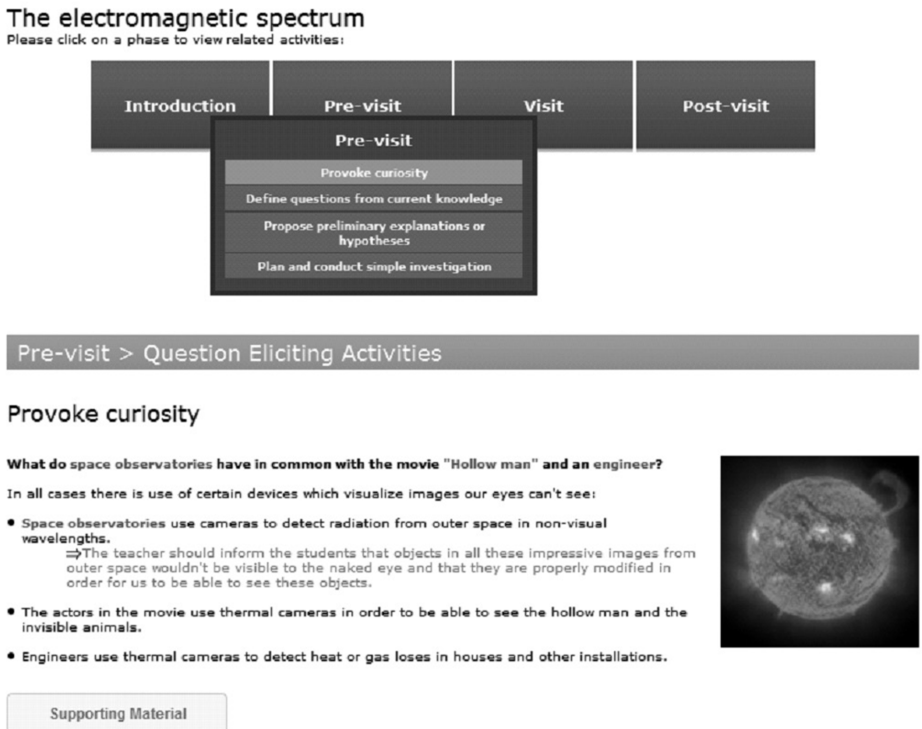


Figure 8.2: A Learning Design (LD) Template example from the COSMOS Repository.

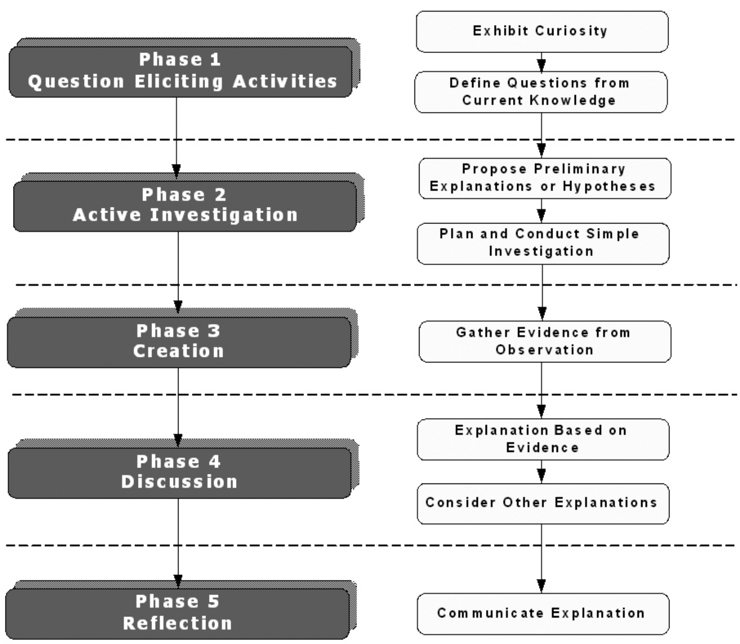


Table 8.2: Overview of the main existing Learning Design Repositories (LDRs)

LDR name	Educational sector	Subject domain	Region coverage	Licence	No. of users	No. of LDs / No. of LD Templates [a]	LDs / LD Templates modelled with IMS LD
The LAMS Repository [b]	All sectors	Cross-disciplinary	International	Open under Creative Commons	6,779	875 / 0	—
iCOPER LD Repository [c]	All sectors	Cross-disciplinary	Regional (Europe)	Open under Creative Commons	N/A	520 / 0	✓
COSMOS [d]	School and higher education	Science education	Regional (Europe)	Open under Creative Commons	2,519	450 / 5	✓
Open Science Resources [e]	School education	Science education	Regional (Europe)	Open under Creative Commons	2,312	158 / 2	—
The Learning Designs Repository [f]	Higher education	Cross-disciplinary	Regional (Australia)	Free under Custom Licence	N/A	32 / 5	—
The Canadian LD Repository [g]	All sectors	Cross-disciplinary	National (Canada)	Free under Custom Licence, openness depending on the LD	N/A	N/A	✓
DialogPlus Repository [h]	All sectors	Cross-disciplinary	National (UK)	Free under Custom Licence, openness depending on the LD	N/A	N/A	✓

a Data retrieved on 10 April 2012.
b www.lamscommunity.org/lamscentral/
c www.icoper.org/repository/learning-design
d www.cosmosportal.eu/
e www.osrportal.eu/
f www.learningdesigns.uow.edu.au/
g www.idld.org
h www.nettle.soton.ac.uk/toolkit/

As we can notice from Table 8.2, four out of seven existing LDRs adopt the IMS LD Specification for modelling their LDs or their LD Templates, whereas the other three use their own internal format. This means that interoperability of LDs/ LD Templates among different existing LDRs is partly facilitated. Moreover, we should note that four out of seven existing LDRs include LDs, which are openly licensed following Creative Commons. This is an important indication that LDs are aligned with the OER openness feature. Next, we discuss in more detail the OpenScienceResources Repository and COSMOS Repository as key representatives of the current state-of-the-art in Web infrastructures that can support open access to educational resources and practices.

The Case of OpenScienceResources Repository

The OpenScienceResources Repository was developed in the framework of an EU-funded project, referred to as "OpenScienceResources: Towards the Development of a Shared Digital Repository for Formal and Informal Science Education" (www.openscienceresources.eu/). It provides access to openly licensed (through Creative Commons) science education LOs and LDs, which can be used by science teachers connecting formal science education in schools with informal science education activities taking place in European science centres and museums. The OpenScienceResources Repository has 2,312 registered users and it includes 3,031 LOs and 158 LDs (data retrieved on 10 April 2012). It follows the institutional sustainability model, meaning an institution (in our case a partner of the specific EU-funded project) undertakes the responsibility to sustain the OER initiative (Downes 2007).

The main functions of the OpenScienceResources Repository include:

- **Store LOs:** The users of the OpenScienceResources Repository are able to store in the repository their LOs along with their metadata descriptions following an LOM Science Education Application Profile (Sampson et al. 2011c).
- **Design and store LDs:** The users of the OpenScienceResources Repository are able to design a new LD according to a pre-defined LD Template, which follows an inquiry-based, pedagogical model (the step-by-step wizard is shown in Figure 8.3). In the final step of this wizard, the user is able to store his or her LD along with its IEEE LOM compatible metadata (Figure 8.4). The LDs that are developed and stored in the OpenScienceResources Repository are not modelled with the IMS LD Specification.

Figure 8.3: OpenScienceResources Repository wizard for designing a new Learning Design (LD).

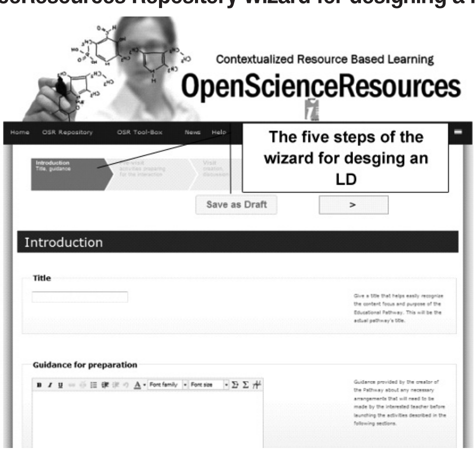
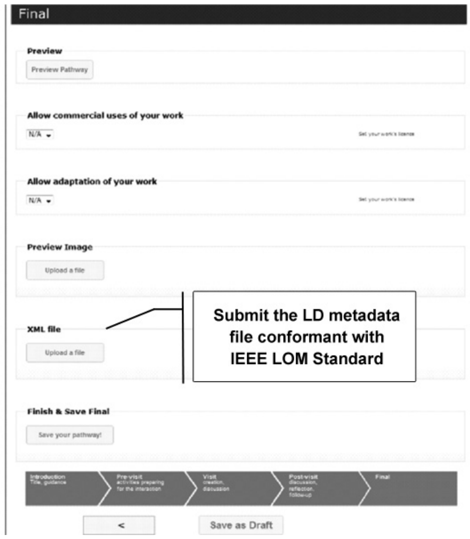


Figure 8.4: OpenScienceResources Repository Learning Design (LD) storage mechanism.



- **Search for LOs and LDs:** The users have the capability of searching, browsing and retrieving LOs and LDs by using terms that are matched with metadata descriptions of LOs and LDs. Figure 8.5 presents the process of searching LOs in the repository.
- **Preview LOs and LDs:** The users are able to preview LOs and LDs. Figure 8.6 presents the process of previewing the structure and the details of a selected LD.

Figure 8.5: OpenScienceResources Repository searching mechanism.

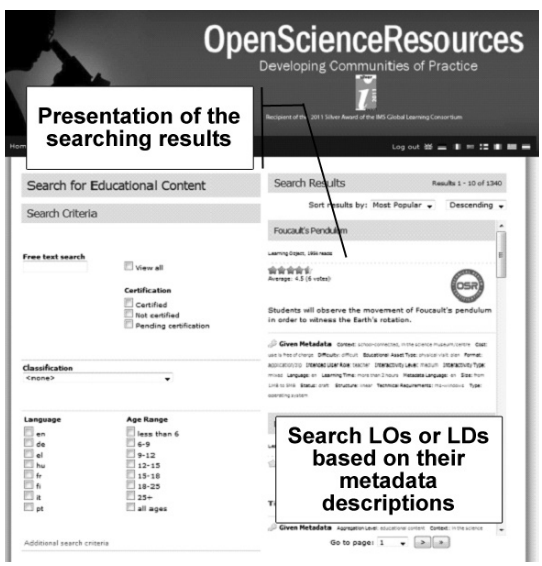
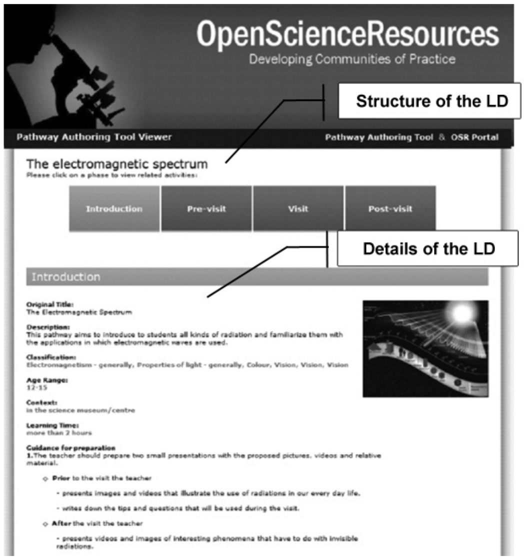


Figure 8.6: OpenScienceResources Repository Learning Design (LD) preview mechanism.



- **Rate/comment on LOs and LDs:** The users are able to provide their ratings and comments for an LO or LD stored in the OpenScienceResources Repository. These ratings and comments could be related with the impressions of the users who have used a specific LO or LD. Figure 8.7 presents the process of rating and commenting a selected LD.
- **View and download LOs and LDs metadata:** The users are able to view in detail the metadata descriptions of LOs and LDs, so as to be able to decide whether or not to use a specific LO or LD. Moreover, the users are able to download the LO or LD metadata in XML format conforming with the IEEE LOM Standard. Figure 8.8 presents the educational metadata of a selected LD and the functions that can be performed.

Figure 8.7: OpenScienceResources Repository ratings and comments mechanism.

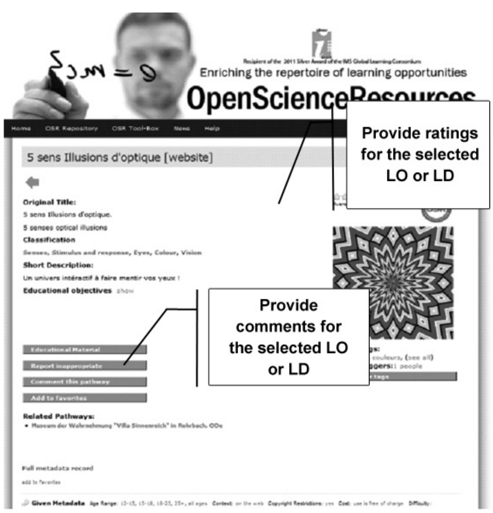
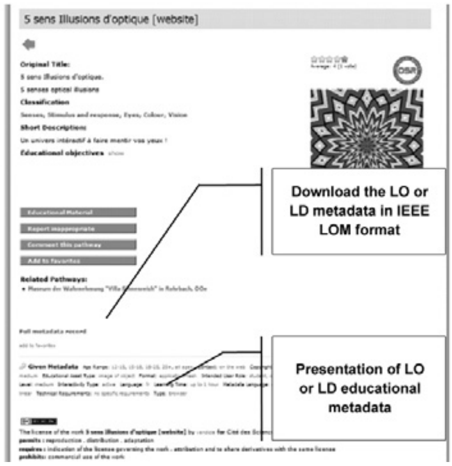


Figure 8.8: View the educational metadata of a selected Learning Learning Object (LO) or Learning Design (LD).



- Add social tagging: The users are able to characterise LOs or LDs by adding tags to them. The OpenScienceResources Repository also provides the capability to its users to search and retrieve LOs or LDs based on the tags added by other users (Sampson et al. 2011a). Figure 8.9 presents the process of adding tags to a selected LD and Figure 8.10 presents the tag cloud that is constructed based on users' tags.

Figure 8.9: OpenScienceResources Repository social tagging mechanism.

Figure 8.10: OpenScienceResources Repository tag cloud.

The Case of COSMOS Repository

The COSMOS Repository was developed in the framework of an EU-funded project, referred to as "COSMOS: An Advanced Scientific Repository for Science Teaching and Learning" (www.cosmos-project.eu/). It provides access to openly licensed (through Creative Commons) science education LOs and LDs for science teachers in school and higher education. The COSMOS Repository has 2,519 registered users and includes 230,128 LOs and 450 LDs (data retrieved on 10 April 2012). Similar to the OpenScienceResources Repository, the COSMOS Repository also follows the institutional sustainability model. The main functions of the COSMOS LD Repository can be summarised as follows:

- **Store LOs, LDs and/or LD Templates:** The users of the COSMOS LD Repository are able to store in the repository their LOs, LDs and LD Templates along with their metadata descriptions following a LOM Science Education Application Profile (Sampson and Zervas 2008). The LDs that are stored in the COSMOS Repository are modelled based on the IMS LD Specification and are developed by using a customised version of the ASK Learning Designer Toolkit (Sampson et al. 2005), which incorporates five LD Templates that are based on different pedagogical models (Sampson et al. 2011b).
- **Search for LOs, LDs and LD Templates:** The users have the capability of searching, browsing and retrieving LOs, LDs and/or LD Templates by using terms that are matched with metadata descriptions of LDs and LD Templates. Figures 8.11 and 8.12 present the process of searching LDs in the COSMOS Repository.

Figure 8.11: COSMOS Repository searching mechanism.

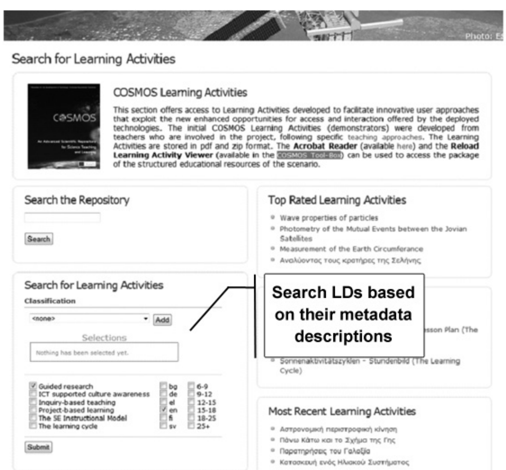
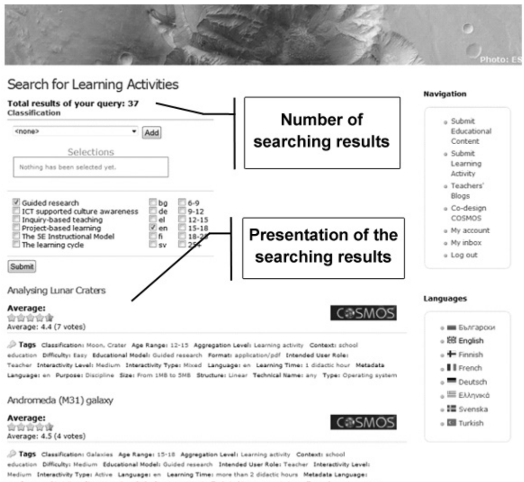
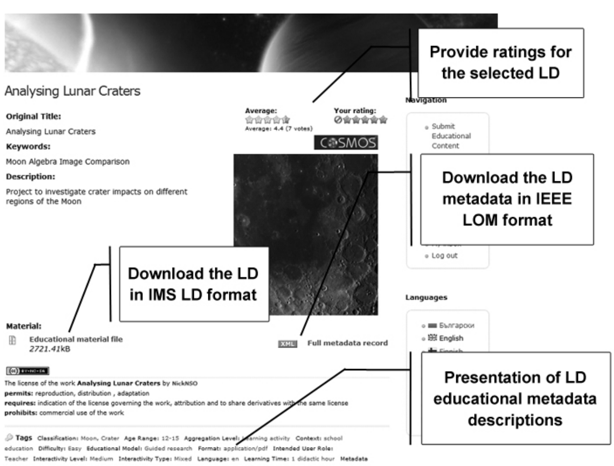


Figure 8.12: Learning Designs (LDs) search results based on selected searching criteria.



- **Download LOs, LDs and/or LD Templates:** The users are able to download LOs, LDs and/or LD Templates (in IMS LD compatible format), as well as their metadata in XML format conforming with the IEEE LOM Standard. Figure 8.13 presents the process of downloading a selected LD and its IEEE LOM compatible XML metadata file.
- **Rate/comment on LDs and/or LD Templates:** The users are able to provide their ratings and comments for the LOs, the LDs and/or LD Templates stored in the COSMOS Repository. These ratings and comments could be related to the impressions of the users who have used a specific LO, LD or LD Template. Figure 8.13 presents the process of providing ratings to a selected LD.
- **View LOs, LDs and/or LD Templates metadata:** The users have the capability of viewing in detail the metadata descriptions of LOs, LDs and/ or LD Templates, so as to be able to decide whether or not to use a specific LO, LD or LD Template. Figure 8.13 presents the educational metadata of a selected LD and the functionalities that can be performed.

Figure 8.13: View the full educational metadata record of a selected Learning Design (LD).

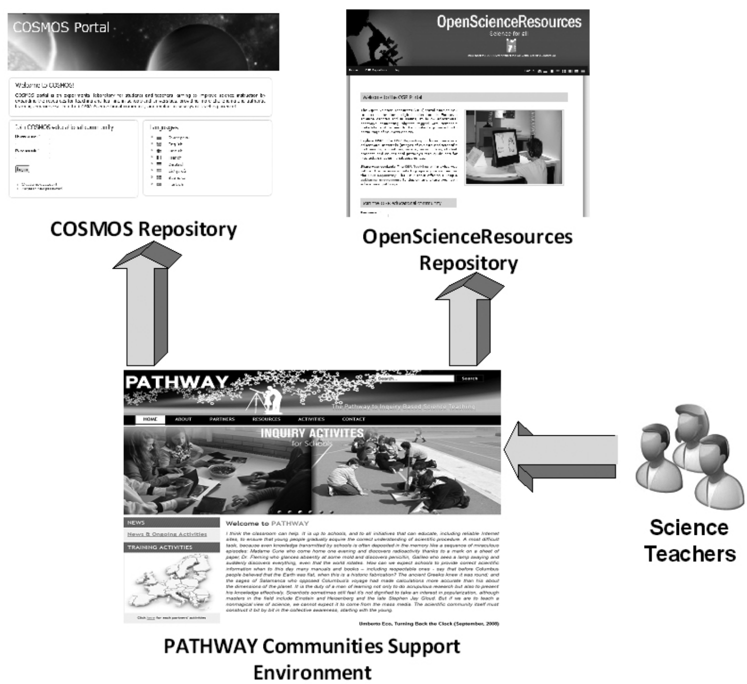


The Case of the PATHWAY Coordination and Support Action

The PATHWAY Project (www.pathway-project.eu) is an EU-funded co-ordination and support action focusing on the effective widespread use of inquiry- and problem-based science teaching practices in primary and secondary schools in Europe and beyond. In this way, the project aims to facilitate the development of communities of practitioners of inquiry that will enable science teachers to learn from each other.

Within this context, sharing, using and repurposing openly licensed science education LOs and best teaching practices in the form of LDs through Web-based repositories are key features for the success of the project. For this purpose, the PATHWAY Project is making use of the OpenScienceResources Repository and the COSMOS Repository for engaging European science teachers in the process of sharing, using and re-using science education LOs and LDs from these repositories. Figure 8.14 presents the overall approach of the PATHWAY Coordination and Support Action.

Figure 8.14: The Approach of the PATHWAY Coordination and Support Action.



As Figure 8.14 shows, science teachers across Europe are becoming members of the PATHWAY Communities Support Environment through a number of participatory engagement workshops that are organised in the framework of the PATHWAY Project. Afterwards, science teachers as members of the PATHWAY community are able to: (a) communicate by using a variety of communication and social networking tools that are integrated into the PATHWAY Communities Support Environment; and (b) share their science education LOs and their teaching practices in the form of LDs through the COSMOS Repository, which targets formal science education, and the OpenScienceResources Repository, which targets informal science education.

Conclusion

In the field of technology-enhanced science education, the process of providing open access to science education resources in the form of LOs and LDs is becoming an emerging trend. For this purpose, both LOs and LDs are organised, classified and stored in Web-based repositories (namely, LORs and LDRs) enabling their open access among science education communities. In this chapter, we discussed issues related with the current trends in Web infrastructures that can support open access to educational resources and practices. We then described two Web-based repositories that facilitate open access to both science education LOs and LDs, and co-ordination and support action that develops a community of science teachers that use these repositories.

At this stage, it is useful to summarise data collected from the use of the aforementioned initiatives:

- An online community of more than 3,000 science teachers from 20 European Countries has been created around the OpenScienceResources and COSMOS repositories.
- The members of this community have made more than 200,000 visits and downloaded more than 35,000 LOs and LDs from both repositories.
- More than 90 per cent of the total LOs and LDs included in these repositories have received comments, ratings and tags related to the actual use of these LOs and LDs by the teachers of the aforementioned community.

These data provided us indications that deployment of Web-based repositories that facilitate open access to both LOs and LDs, which also address specific subject domains (in our case Science Education), can make those repositories more attractive for use by teachers compared with broader LORs and LDRs, where teachers might face difficulties in the process of finding and using appropriate LOs and LDs for the subject domain of their interest.

Finally, the three initiatives presented in this chapter offer the infrastructure that will be integrated under a new European initiative referred to as "Open Discovery Space: A Socially Powered and Multilingual Open Learning Infrastructure to Boost the Adoption of eLearning Resources." The Open Discovery Space (www.opendiscoveryspace.eu/) aims to include more than 1.5 million LOs and LDs by aggregating open licensed LOs and LDs from a federated network of 75 existing LORs and LDRs in Europe. The main outcome of the Open Discovery Space project will be a community-oriented social platform where teachers, students and parents from all around Europe will be able to search and retrieve LOs and LDs on their topics of interest. It is expected that at the end of the Open Discovery Space project, the Open Discovery Space portal will be the biggest federated network of existing LORs and LDRs in the world.

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