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Author(s): AIE, Cineca

Partner(s) Contributing: Nielsen Book Data, INDIRE

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Project Co-ordinator

Company name : *CINECA*
Name of representative : *Gabriella Scipione*
Address : *via Magnanelli 6/3 -40033 Casalecchio di Reno (Bologna), Italy*
Phone number : *+ 39 051 6171634*
Fax number : *+ 39 051 6132198*
E-mail : *g.scipione@cineca.it*
Project WEB site address : *www.eleonet.org*

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1. Executive Summary

Task **3.2** consisted of an in-depth analysis of the existing metadata schemas applicable to learning objects, both specific (such as LOM standard) and multipurpose (such as Dublin Core and ONIX)[1]. The specific objective of the study was to analyze existing metadata standards from two points of view: the technical one, as to define a framework for the interoperability between Eleonet and the different applications/IT systems within the e-learning value chain, and the "market" point of view, as to better understand the current needs of the main actors involved in the e-learning sector, thus encouraging their participation in the project.

Indeed, the Eleonet metadata schema should be rich enough to provide an adequate description of learning resources and to ensure the maximum degree of interoperability with other existing standards; at the same time, it should be simple enough to be manageable for publishers and content producers at the moment of the upload of metadata during the registration.

Therefore the main outcome of the metadata survey has been the definition of a common basis for an Eleonet schema that encompasses the existing ones providing a pragmatic solution for LOs producers. This means that the Eleonet schema is not to be considered as a new standard in competition with the existing ones, but, on the contrary, it establishes a subset of broadly adopted metadata elements from the existing metadata schema for learning resources with the objective to allow everyone to continue using the already adopted schema, but registering DOIs and entering the Eleonet system with a minimum adaptation.

The methodology adopted for the survey can be summarized as follows:

- **Desk analysis** of existing metadata schema currently used within the international content industry: this preliminary study focused on the comparison between multipurpose and LOs-specific metadata standards, pointing out that the LOM metadata schema is to be considered the most suitable choice for Eleonet metadata repository. This resulted both from a technical evaluation -that is that multipurpose metadata standards don't allow an adequate description of specific characteristics of educational resources - and from strategic considerations – that is, with the LOM standard widely adopted at international level, it ensures Eleonet a higher degree of interoperability with many other LOs repositories.
- **Strengths and Weaknesses analysis**: once it was decided to adopt the LOM standard for the Eleonet system, the analysis proceeded with the evaluation of the main advantages and limits of different LOM application profiles considered in the metadata survey. In order to establish an Eleonet application profiling strategy, the analysis focussed on the capability of different LOM APs to fulfil SCORM platforms' requirements, the capability of LOM metadata to communicate rights and licensing information and how customized extensions to LOM base schema could affect semantic and syntactic interoperability issues.
- **Elaboration of the Eleonet metadata strategy**: the experiences of the previous projects considered in the survey provided the basis for the definition of the Eleonet strategy. Indeed, the strength and weaknesses analysis pointed out the relevance of SCORM compliance and interoperability issues as important goals to be achieved. At the same time, the market facts need to be carefully considered, particularly because LOs providers are not used to manage metadata and should not be asked to provide too much mandatory information to enter Eleonet system. As a consequence of this, a key issue driving the Eleonet strategy has been the balancing between the market facts and the need to describe LOs adequately from a bibliographic and educational point of view.
- **Eleonet approach to interoperability issues**: as far as semantic interoperability is concerned, in building up the Eleonet metadata schema special attention was paid to LOM

[1] For an overview of the mentioned standards, see section *2.Desk Analysis.*

vocabularies, that is the lists of values that can be use to describe the educational resource. In order to enhance semantic interoperability, different customized LOM vocabularies have been compared and merged together when appropriate. With respect to syntactic interoperability, the survey pointed out that simplification of the LOM base schema could affect the capability of information exchange between different IT system; therefore, the importance of maintaining the full complexity of the LOM data model has been recognised by implementing the full LOM XML schema.

- **Metadata for search and display**: having defined the Eleonet metadata specifications, the role of metadata for the Eleonet search engine and catalogue display were focused on, as to outline which data elements collected by the system during DOI registration could be used for structured and for full text searches as well as for display purposes to final users.

2. Desk Analysis

In order to ensure the full interoperability between Eleonet metadata repository and the most widespread metadata schemas within the e-learning environment, the desk analysis took into consideration both specific (such as LOM) and multipurpose metadata schemas (such as Dublin Core and ONIX); moreover, as the comparison between multipurpose and LOs specific metadata pointed out that the most suitable schema for the Eleonet system was for it to be based on the LOM data model, it has been necessary to look at the different LOM metadata Application Profiles[2] developed by individual organizations within LOM framework, thus eventually establishing which data elements and related values lists are mainly used within LOs repositories.

2.1 Multipurpose metadata standards

As far as multipurpose metadata standards are concerned, the Eleonet survey took into consideration two widely adopted standard communication formats employed within the content industry:

- The *Dublin Core* metadata element set[3], produced within the ISO framework (ref. code ISO DIS 15836)
- The *ONIX for Books* product information message[4] (version 2.1), developed and maintained by EDItEUR jointly with Book Industry Communication (UK) and the Book Industry Study Group.

2.1.1 Dublin Core Metadata Element Set

Dublin Core standard was developed to provide a very simple "lowest common denominator" set of 15 elements that could be used for the description of any types of online resource. It's purpose is perhaps best described by quoting directly from the NISO Standard (Z39-85): "The Dublin Core is not intended to displace any other metadata standard. Rather it is intended to co-exist — often in the same resource description — with metadata standards that offer other semantics. It is fully expected that descriptive records will contain a mix of elements drawn from various metadata standards, both simple and complex […] "The simplicity of Dublin Core can be both a strength and a weakness. Simplicity lowers the cost of creating metadata and promotes interoperability. On the other hand, simplicity does not accommodate the semantic and functional richness supported by complex

[2] The concept of application profile will be deeply illustrated in section *3.2* of this document.

3 Dublin Core Metadata Initiative's full documentation is available at http:// www.dublincore.org

[4]ONIX refers to a family of standard formats (comprising Onix for Books) all basing on the same syntax, developed and maintained by EDItEUR for electronic commerce in content industry. Onix formats and related documentation are available at EDItEUR official website: http://www.editeur.org

metadata schemes. In effect, the Dublin Core element set trades richness for wide visibility… Richer schemes can…be mapped to Dublin Core for export or for cross-system searching."[5]
In the e-learning environment, the Australian project Edna Online (Education Network of Australia)[6], a national framework developed since 1998 for collaboration on the use of the Internet in education and training, is an example of a project which adopted a multipurpose metadata schema, the Dublin Core, as the basis for the development of framework describing resources for the school education sector.
As EDNA experience clearly shows, the descriptive information included in a Dublin Core metadata record necessarily requires it to be integrated with other specific information that has educational relevance. This can be done by either defining education-specific elements, element refinements or encoding schemes.
Therefore, as multipurpose metadata schema are to be significantly extended with further elements to adequately describe learning objects, it could be argued that such resources require a metadata schema specifically designed for managing content within the learning environment.

2.2 Dublin Core Metadata Element Set

ONIX is the international standard for representing and communicating book industry rich product information in electronic form between business partners in the supply chain, including applications for serials and video as well as books. ONIX was developed initially by the book and serials industries in the USA and UK and is now being implemented by other countries as an international standard for exchanging information about products based upon published material. The application of ONIX is typified by, but by no means restricted to, the supply of information on new, revised and re-issued publications by publishers to their supply chain partners. ONIX was influenced by the work of the EU <indecs> project and the IFLA Functional Requirements for Bibliographic Records. The development and application of ONIX is controlled by EDItEUR, an international organisation consisting of publishers, booksellers, bibliographic agents, wholesalers, libraries and other partners in the publishing supply chain.
In order to evaluate the prospects for the implementation of a new ONIX format aimed at describing LOs, a mapping between ONIX for Books (Release 2.0) and SCORM (The Sharable Content Object Reference Model, a set of standardized procedure specifically developed for managing LOs within Learning Management System including a specific LOM metadata Application Profile[7]) was prepared in 2001 by EDItEUR on request of the Association of American publishers.
As shown by the mapping from SCORM to ONIX (see ANNEX 1) the relationships between the data elements of an ONIX product description and the meta-data elements of a SCORM learning content resource is not simple, as only in a few cases is there a direct correlation between ONIX and SCORM elements.
As demonstrated by the two aforementioned case histories, while a learning object is a specific type of resource which requires a metadata schema specifically designed to represent its peculiar characteristic, a multipurpose metadata schema only provides a general framework for communicating data about content regardless of the context where it will be used.
Indeed, when a content object is to be used for educational purposes it needs to be described using metadata specific to the learning environment which does not correspond with non-LOs-specific metadata standards.

5 2001, Dublin Core Metadata Element Set v1.1 NISO Standard Z39.85-2001: http://www.niso.org/standards/resources/Z39-85.pdf
6 See also Edna Online: http://www.edna.edu.au/ and Edna metadata schema: http://www.edna.edu.au/edna/go/engineName/filemanager/pid/385/edna_metadata.doc?actionreq=actionFileDownload&fid=4864.
7 The SCORM meta-data elements provided in SCORM CAM are identical to those defined in IEEE LOM Draft standard for learning objects metadata (http:// http://ltsc.ieee.org/wg12/files/LOM_1484_12_1_v1_Final_Draft.pdf); see http://www.adlnet.gov/scorm/index.cfm for SCORM full documentation.

2.3 Learning objects – specific metadata

The Eleonet survey took into consideration several national and international projects dealing with learning objects:

- **ARIADNE** (EU)[8]: A European Association open to the World, for Knowledge Sharing and Reuse. The core of the ARIADNE infrastructure is a distributed network of learning repositories. ARIADNE have been collecting learning objects and metadata in the Knowledge Pool System for more than 9 years. Recently, as the XML binding of LOM matured, ARIADNE metadata model has been mapped into LOM XML instances. This increases the interoperability between ARIADNE and other Learning Object Repositories that rely on IEEE LOM.[9]
- **Cancore** (CAN)[10] The *CanCore Metadata Initiative* assists project implementers and indexers in the development of high-quality systems and records to support the use and reuse of digital learning objects. LOs can be as simple as individual web pages, video clips, or as comprehensive as full courses or training programs. CanCore has been working with an expanding community of implementers since November 2000. It provides guidelines for all of the elements in the LOM standard, and identifies a sub-set of these elements for their special utility in resource description and discovery.
- **Celebrate** (EU)[11] *Context eLearning with Broadband Technologies* was a large-scale 30-month demonstration project (ending in Nov. 2004) co-ordinated by European Schoolnet and supported by the European Commission's Information Society Technologies Programme (IST). During the project the CELEBRATE portal has been made available to up to 500 schools in six countries (Finland, France, Hungary, Israel, Norway and the UK) which get access both to a LOs database and a virtual learning environment. To support the exchange of information about online digital resources, a specific LOM Application Profile has been developed.
- **CORDRA** (US)[12]. CORDRA stands for *Content Object Repository Discovery and Resolution Architecture*. The project aims at creating a standards-based infrastructure for the discovery, sharing and reuse of learning content through an interoperable federation of learning content repositories; in order to enhance interoperability among the federation of CORDRA repositories, the system will be based on the LOM standard. At present the project is under development, focusing on the possibility to use DOIs to register and keep track of learning objects in distributed repositories
- **Curriculum Online** (UK)[13] Started in 2003, the Curriculum Online portal consists of an online catalogue comprising thousands of free and priced multimedia resources indexed and described according to the LOM data model. School teachers can search for resources based on a variety of criteria relevant to the resource such as the subjects, key stages and school years. A freely available tool is provided to help suppliers in this process to provide catalogue records in the form of LOM metadata
- **DIGISCUOLA** (IT)[14] was promoted by the Italian Minister for Innovation and Technologies in concert with the Ministry for Education, Universities and Research. The project will provide for digital content development to support teaching, and the introduction of new technologies in learning processes. This will be achieved through a

[8] ARIADNE documentation is available at: http://www.ariadne-eu.org/
[9] For a detailed presentation of ARIADNE work on LOM metadata model, see J. Najjar, E. Duval, S. Ternier, en F. Neven, *Towards interoperable learning object repositories: the Ariadne experience*, available at http://www.cs.kuleuven.ac.be/~hmdb/publications/publicationDetails.php?id=41268
[10] CanCore Learning Resource Metadata Initiative: http://www.cancore.ca/en/index.html
[11] Celebrate official website: http://celebrate.eun.org/eun.org2/eun/en/index_celebrate.cfm
[12] CORDRA documentation is available at http://cordra.net
[13] Curriculum Online portal is available at http:// www.curriculumonline.gov.uk
[14] DigiScuola website: http://www.digiscuola.it

National Technological Platform for the input, storage and use of Learning Objects. From September2006 more then 500 upper-secondary schools shall have the access to a repository of educational resources on a trial basis during the whole school year.

- **LON** (US)[15] Founded in 2000, *Learning Objects Network, Inc.* (LON), launched a project in collaboration with the Department of Defence in the US to identify LOs produced by private publishers with DOIs and thus to facilitate the re-use of such content. Moreover, LON offers consulting services to help publishers to create granular, reusable, and interoperable educational content. Through a strategic partnership with the publishing industry's trade association, the Association of American Publishers (AAP), LON is supporting the commercial adoption of SCORM conformant learning objects. Learning Objects Network's educational and consulting services assist companies in assessing the impact of SCORM on their businesses and in achieving SCORM conformance.

As resulted from the analysis of these projects, the existing and most internationally widespread metadata specifications for LOs are all based on the same standard, LOM - Learning Object Metadata, though with slight customizations[16].
In other terms, Eleonet metadata survey highlighted that most of European and International LOs repositories rely on various LOM Application Profiles, resulting from the selection of different LOM metadata subset, extended, if necessary, with additional data elements addressed to each project's specific purposes.

2.3.1 LOM – Learning Object Metadata Standard [17]

LOM aims to specify the syntax and semantics of Learning Object Metadata, allowing to highlight the core features of a learning object, as its metadata focus on specific features of educational content objects in a digital learning environment, such as pedagogical, structural, technical qualities but also relationships between learning resources.
For the purpose of this document, it is sufficient to remark that, unlike multipurpose metadata standards, LOM describes some core characteristics of a content object within a learning environment. Such characteristics may be grouped in general, life cycle, meta-metadata, educational, technical, educational, rights, relation, annotation, and classification categories.

- The *General* category groups the general information that describes the learning object as a whole.
- The *Lifecycle* category groups the features related to the history and current state of this learning object and those who have affected this learning object during its evolution.
- The *Meta-Metadata* category groups information about the metadata instance itself (rather than the learning object that the metadata instance describes).
- The *Technical* category groups the technical requirements and technical characteristics of the learning object.
- The *Educational* category groups the educational and pedagogic characteristics of the learning object.
- The *Rights* category groups the intellectual property rights and conditions of use for the learning object.
- The *Relation* category groups features that define the relationship between the learning object and other related learning objects.

[15] LON official website: http://www.learningobjectsnetwork.com
[16] For a detailed comparison between different LOM Application Profiles, see also the International LOM Survey final report (http://dlist.sir.arizona.edu/403/); this survey on the use of LOM was carried out in 2004 and showed that major educational portals use LOM, though the educational section was generally underused.
[17] IEEE-1484.12.1-2002 Draft standard for learning object metadata is available at: http://ltsc.ieee.org/wg12/files/LOM_1484_12_1_v1_Final_Draft.pdf

- The *Annotation* category provides comments on the educational use of the learning object and provides information on when and by whom the comments were created.
- The *Classification* category describes this learning object in relation to a particular classification system.

It must be noted that some of the LOM metadata categories, particularly, Educational, Relation and Annotation, focus on specific features of learning resources as to be suitable to the specific needs of the educational environment.
Particularly, LOM standard has many purposes: to enable learners or instructors to search, evaluate, acquire, and utilize Learning Objects; to allow the sharing and exchange of Learning Objects across any technology supported learning systems; to enable the development of learning objects in units that can be combined and decomposed in meaningful ways; to provide education, training and learning organizations, both government, public and private, a standardized format that is independent of the content itself; to provide researchers with standards that support the collection and sharing of comparable data concerning the applicability and effectiveness of Learning Objects.

3. Strengths and Weaknesses Analysis

In order to provide a real added value to Eleonet users, the DOI APs for LOs has been defined taking into account strengths and weaknesses **of the aforementioned LOM Application Profiles**[18]:

3.1 The concept of Application Profiles

Even if the most internationally widespread metadata schema for LOs are all based on the LOM standard, they differ from each other regarding what is generally called their "Application Profile".
With its recent approval as a standard (IEEE 2002), LOM data model has achieved a level of stability and international recognition requisite to its implementation in large-scale e-learning infrastructures. "As a part of this development and implementation process, the LOM is being refined and adapted by a wide variety of consortia and projects to meet the requirements of specific communities and domains"[19].
As different Learning Object Repositories try to address the needs of different Learning Communities within their own educational contexts, each LOM metadata Application Profile considered in the survey results from a personalization of the standard, so that each LOM Application Profile has been built up by selecting a number of LOM metadata elements and adapting, where possible, their related value sets to the current requirements of a specific learning community.
Therefore, even if the existence of a number of LOM Application Profiles demonstrates the wide acceptance and recognition of this metadata schema at international level as the main standard for Learning Objects metadata, there also arises some issues about semantic and technical interoperability within the e-learning value chain.

3.2 Interoperability between LOM APs

Being designed for exhaustively describing modular, reusable, and specifically educational resources, LOM data model consist in a complex structure, covering a wide variety of LOs characteristics. Moreover, according to the standard, all the 76 metadata elements provided by LOM are optional and extensions of LOM base schema are allowed for customization purposes.

[18] See section *2.2 Learning Object – specific metadata*
[19] *Semantic and syntactic interoperability for Learninig Object Metadata*, Cancore Documents & Presentations, www.cancore.ca/semantic_ and_syntactic_interoperability

Given the composite and complex structure of LOM and the high degree of freedom allowed in customization, several LOM APs tend to simplify LOM data model and, at the same time, to undertake customized extensions[20], thus reducing "technical interoperability" between IT systems. This simplification puts systems which are incapable of processing and storing the full LOM element set at the risk of truncated records from other systems they might receive, store, then retransmit, with a consequent loss of information.
As far as semantic interoperability is concerned, it refers to the meanings embedded in LOM value lists (the so-called LOM vocabularies) which tend to be adapted to national curricula and specific educational contexts; this leads to difficulties in taking further a country-based approach to the representation of the educational system and in defining a shared classification and indexing system for LOS, especially when dealing with educational projects at European level[21].

3.3 SCORM Compliance

The analysis revealed that most LOM application profiles considered have not been defined in full compliance with SCORM[22] platforms requirements.
SCORM compliance is not achieved neither by Curriculum Online, nor by Celebrate[23] project, while in the case of CORDRA, SCORM requirements have been just partially followed: "While the prototype CORDRA registry will be an ADL Registry of SCORM-conforming content objects for deployment by the US government, CORDRA registries are not limited to including information about SCORM content"[24]
In other terms, the survey found that only a few projects try to fulfill SCORM requirements :

- **CanCore** : in compliance with SCORM, the CanCore element set includes all 11 elements that SCORM identifies as mandatory for Raw Media materials.
- **LON**: the LON Registry has been specifically designed to store IMS and SCORM-conformant metadata and meets the current specifications for IEEE Learning Object Metadata.
- **DIGI SCUOLA**: LOM application profile developed within the context of DIGI Scuola project have been specifically designed in order to achieve a full SCORM compliance.

SCORM (Sharable Content Object Model) is "a collection of standards and specifications adapted from multiple sources to provide a comprehensive suite of e-learning capabilities that enable interoperability, accessibility and reusability of Web-based learning content"[25].
By defining a set of standardized procedures for managing the interaction between LOs and final users within a digital environment, SCORM represents the main standard on which current Learning Management Systems are based. Particularly, SCORM defines an aggregation model for packaging learning content objects, an API (Application Programming Interface) to enable communications between learning content and the system that launches it and a set of navigation and sequencing rules enabling SCORM conformant content to be sequenced through a set of navigation events.
A SCORM conformant content unit is to be described by a specific set of LOM metadata, which can be directly packaged together with the learning resource they refer to or collected in catalogues; in any case, metadata is crucial for the effectiveness of the content workflow within the LMSs because it is required to enable the system to locate content components, aggregate them in larger units (e.g., a LO, a lesson, a course, etc.), and manage them during the learning experience.

[20] An example of LOM APs that both simplify and undertake customized extensions of the LOM is Curriculum Online Project, 2003.
[21] For Eleonet approach to interoperability issues, see section 4. 3 *Interoperability Issues*
[22] SCORM refers to a set of standards developed by ADL (advanced Distributed Learning) for managing Learning Objects in a web based environment. All SCORM documentation is freely available at http://www.adlnet.gov/scorm/index.cfm
[23] For a more detailed presentation of SCORM Conformance Requirements, see section 4.1 *LOM mandatory data elements*
[24] See CODRA FAQ at http://cordra.net
[25] See SCORM website: http://www.adlnet.gov/scorm/index.cfm

Moreover, LMS uses metadata to give the learner information referring to the content which is about to be used and to decide within a run-time environment the appropriate content model component which is to be delivered to the learner.
The **SCORM CAM** (*Content Aggregation Model*) directly references the IEEE 1484.12.1-2002 Learning Object Metadata (LOM) as the preferred standard for creating valid SCORM metadata instances, imposing at the same time, additional constraints on LOM data elements and related values[26].
The lack of SCORM compliance represents one of the main weaknesses of many LOM application profiles considered in the metadata survey: as SCORM compliancy is not fully achieved, this prevents the efficiency of the communication flow in the e-learning value chain, thus reducing the opportunity for LOs producer to re-use their LOM metadata record in multiple contexts (i.e. not only in ELEONET metadata catalogue but also within e-leaning platforms or any other online database) as to increase the visibility of their LOs in the final market.

3.4 Rights and Licensing Information

LOM data model itself doesn't provide a structured way for describing rights and licensing information; on the contrary, the LOM section "Rights" only allow to specify whether a resource is free or priced, whether copyrights restrictions apply to the LO and eventually a free – text field to state a full copyright description.
The lack of a standard way for expressing rights and licensing models affects the actual interoperability of different LOM application profiles which generally undertake customized extensions to LOM data model or alternatively manage a rights information flow separately (i.e. using a Digital Rights Management System).
With respect to rights and licensing issues, the Eleonet approach is to carry on further studies on rights communication formats aimed at verifying the most suitable way of communicating such information using a standard language.
Indeed, even if the LOM standard allows Rights metadata section to be extended by further data elements enabling a more detailed description of the terms and conditions of LOs usages, it must be carefully taken into account the importance of extending LOM data model just using a widely agreed metadata format for rights and licensing terms.

4. Eleonet approach

The development of Eleonet metadata specifications for DOI registration have been driven by the following issues:

- Need to be SCORM compliant: in order to offer a real added-value to LOs producers, Eleonet metadata record should be re-usable in SCORM environment, i.e. without requiring additional information to be provided by producers to launch their LOs in Learning Management Systems.
- Need to encourage LOs producers to take part in the Eleonet Network, thus offering a practical solution for DOI registration, i.e without asking LOs producers for too many mandatory data elements.
- Need to provide an adequate description of LOs from the educational, rights and bibliographic point of view, thus increasing LOs visibility and searchability: once defined a minimum LOM subset of mandatory data elements, other optional metadata have been added to Eleonet metadata specification thus providing an adequate description of educational resources.

[26] For a more detailed presentation of SCORM Conformance Requirements, see section 4.1 *LOM mandatory data elements*

- Need to enforce interoperability with the existing and widely used LOM APs: the choice of LOM metadata elements and related value list have been made taking into account both national (i.e. Curriculum Online and Digi Scuola) and European Projects dealing with LOs (i.e. Celebrate)

4.1 LOM mandatory data elements

An Eleonet mandatory data elements subset has been developed according to SCORM Metadata Application Profile Requirements (see SCORM CAM 2004, v1.3.1) which defines the integration of LOM metadata instances within the SCORM environment.
From a strategic point of view, this choice allows the definition of a minimum set of mandatory information that could be supplied by DOIs Registrants without too much effort - thus encouraging them to take part in the Eleonet project - ensuring at the same time the interoperability with SCORM - based IT systems.
While LOM standard allows organizations to create their own metadata application profile with the highest degree of freedom, SCORM Metadata Application Profile Requirements impose additional constraints on the IEEE LOM metadata Draft Standard.
SCORM additional requirements or constraints can be described as:

- **Mandatory data elements**: while LOM indicates that all the data elements are optional, SCORM requires as mandatory some of the LOM data elements when creating a SCORM-conformant metadata instance.
- **Use of Vocabularies**: A LOM vocabulary is a recommended list of appropriate values. SCORM describes the LOM vocabularies in two ways: Restricted and Best Practice. If a vocabulary is identified as Restricted, SCORM requires the use of the LOM vocabulary. If a vocabulary is identified as Best Practice, SCORM suggests the use of the LOM vocabulary, however organizations are free to extend the meta-data instances with their own vocabulary

Indeed, as remarked in SCORM CAM, if no requirements were made on which elements and values to use when creating LOM meta-data instances, then the opportunities for search and discoverability within repositories and other systems would potentially diminish. On the contrary by placing requirements on which sets of data elements and related values are mandatory for use in meta-data instances, the opportunity for enabling search, discoverability and reuse are increased.
The table below illustrates LOM mandatory data elements[27] as defined in SCORM Metadata Application Profile Requirements, retaining the valuespace and datatypes required to achieve SCORM compliance. Such LOM metadata subset will be implemented in Eleonet system as the mandatory data elements for DOI registration on LOs.

[27] For clarity purposes, table 1 doesn't show neither parents elements (that is, aggregate data element which don't carry any value) nor metadata that will be automatically provided by Eleonet system. In other term, the table summarizes just the information which is to be directly provided by the LOs producer.

Table 1. Scorm mandatory data elements

Nr	Name	Value (examples)	Description
1.1. 2	**General. Identifier. Entry** (SCORM:M)	10.1392/digital_object_1	The value of the identifier within the identification or cataloging scheme that designates or identifies this learning object. A namespace specific string.
1.2	**General. Title** (SCORM:M)	"The life and works of Leonardo da Vinci"	Name given to this learning object.
1.4	**General. Description** (SCORM:M)	"In this video clip, the life and works of Leonardo da Vinci are briefly presented. The	A textual description of the content of this learning object
1.5	**General. Keyword** (SCORM:M)	"Mona Lisa", "Leonardo da Vinci"	A keyword or phrase describing the topic of this learning object.
2.1	**Life Cycle. Version** (SCORM:M)	"1.0"	The edition of this learning object.
2.2	**Life Cycle. Status** (SCORM:M)	"Final"	The completion status or condition of this learning object. Vocabulary (SCORM): -Draft -Final -Revised -Unavailable
4.1	**Technical. Format** (SCORM:M)	"text/html", "video/mpeg"	Technical datatype(s) of (all the components of) this learning object. Mime types or "non digital"
6.1	**Rights. Cost** (SCORM:M)	Yes	Whether use of this learning object requires payment. Vocabulary (SCORM): -Yes -No
6.2	**Rights. Copyright and Other Restrictions** (SCORM:M)	Yes	Whether copyright or other restrictions apply to the use of this learning object. Vocabulary (SCORM): -Yes -No

Nevertheless, as results from a deeper evaluation, the LOM metadata in table 1 provides neither an adequate description of the educational resources nor an adequate number of elements to be used for searching them within the Eleonet catalogue, though ensuring SCORM compliance.
Particularly, the SCORM mandatory metadata subset illustrated above doesn't enable publishers to describe adequately the resources neither from an educational point of view (for example, there are no fields for describing the learning resource type or the intended educational context where the resource is to be used) nor from the rights management point of view (at least a field enabling a full copyright statement should be added) nor from a bibliographical point of view (at least the publisher name should be collected).
As far as search options are concerned, the minimum subset of mandatory metadata in the table above enables users just to search LOs by *title*, *Identifier*, *keywords* and by *full text searches* on LOs *title* and *description*; finally, element 6.1. *cost* could be used to allow users to specify whether they are looking for free or priced resources.

Therefore, in order to enable final users to search inside the Eleonet catalogue by further relevant educational criteria (such as teaching subjects), other optional metadata elements enabling the classification and indexing of educational resources are to be added to DOI APs for LOs[28].,

[28] See section 4.2 *LOM Optional Data Elements*

4.2 LOM Optional Data Elements

Once established the minimum mandatory LOM metadata set required for Eleonet - DOI AP, consideration is needed over which metadata could be optionally collected in Eleonet system thus completing the description of learning resources and improving LOs searchability.
Moreover, optional data elements should be selected so as to fulfill the goal of interoperability between Eleonet and other national and European LOs repositories.
Table 2 illustrates optional metadata which are strongly suggested to be included in Eleonet metadata records[29] so as to:

- Provide a more complete description of the LOs: some metadata are suggested for inclusion because they carry important educational, bibliographical, copyright information.
- Improve the searchability of LOs: some metadata are suggested for inclusion because they make LOs more searchable by final users.
- Foster interoperability between Eleonet system and other national and European LOs repositories implementing other LOM APs (see section **4.3**)

Table 2. Eleonet optional data elements

Nr.	Name	Value (example)	Description
1.3	**General. Language**	"English"	The language of the learning object.
2.3.1	**Life Cycle. Contribute. Role**	"Author" or "Publisher"	It should be recommended to describe at least the author and/or the publisher of the Learning Object
2.3.2	**Life Cycle. Contribute. Entity**	"John Smith"	The name of the author and /or the name of the publisher
2.3.3	**Life Cycle. Date**	"2001-08-23"	The date of the contribution
4.3	**Technical. Location**	10.1392/digital_object_1	The string that is used to access this Learning object. **Note:** If used to specify the DOI string that resolves to the LO, this field must be considered mandatory (regardless of SCORM conformance requirements)
5.2	**Educational. Learning Resource Type**	"exercise" + "lecture"	Specific kind of learning object. The most dominant kind shall be first. Vocabulary based on LOM and Celebrate: self assessment exercise experiment lecture problem statement simulation exam/questionnaire case study tutorial Educational game questionnaire information resource Glossary Open Activity Tools Note: for a greater level of interoperability with Curriculum Online resource, the values "Open Activity" and "Tools" have been added to the vocabulary
5.6	**Educational. Context**	"primary school"	The principal environment within which the learning and use of this learning object is intended to take place. Vocabulary based on CELE BRATE; This vocabulary will be compared with Curriculum Online vocabulary for possible extensions.

[29] For clarity purposes, table 2 doesn't show neither parents elements (that is, aggregate data element which don't carry any value) nor metadata that will be automatically provided by Eleonet system. In other term, the table summarizes just the information which is to be directly provided by the LOs producer.

5.7	**Educational. Typical Age Range**	8-10	Age of the typical intended user.
6.3	**Rights. Description**	("en", "Use of this learning object is only permitted after a donation has been made to Amnesty International.") "Copyright © Scorchio ES LTD 2002"	Comments on the conditions of use of this learning object. **Note** : Curriculum Online uses this field for carrying the copyright owner and copyright year.
9.2.2.2	**Classification. TaxonPath. Taxon. Entry**	"Arts"	A specific entry in a classification scheme;
9.4	**Classification. Keywords**	"history of arts" + "art movement"+ "15th century"	If a thesaurus is implemented as indexing system, keywords are formally "descriptors" extracted from the thesaurus.

4.3 Interoperability issues

In order to ensure an higher degree of semantic and syntactic interoperability between Eleonet and other IT systems based on LOM standard, optional data elements added to SCORM mandatory subset have been selected taking into account other national and Eurpean LOs repository, particularly :

- **Curriculum Online**. Eleonet AP preserves as optional metadata most of Curriculum Online mandatory data elements, but doesn't retain Curriculum Online resources classification schemes; indeed, such classification schemes refer to UK education system criteria, such as the National Curriculum Programme of Study and thus are not suitable for classifying educational resources at European level.

- **Celebrate (EU)**
  This project is specifically concerned with developing and accessing digital multilingual learning objects and assets across Europe and to ensure their interoperability by following LOM standard. Given its wide scope, which focused on the whole European learning environment, Celebrate metadata model and vocabularies have been taken into great consideration when developing Eleonet metadata specifications, especially as LOM category *Educational* is concerned.

- **DIGI SCUOLA Project (Italy)**. DIGI SCUOLA repository implements a LOM application profile edited by AIE and INDIRE which is largely based on Celebrate (as far as LOM vocabularies are concerned) as well as on SCORM Metadata Application Profile Requirements.

4.3.1 Semantic Interoperability

As far as semantic interoperability is concerned, special attention is to be paid to LOM vocabularies.
In order to provide a description of learning resources broad enough to be suitable for the European educational context, ELEONET LOM APs includes some extended vocabularies.
According to IEEE-1484.12.1-2002 Draft standard for learning object metadata: "A vocabulary is a recommended list of appropriate values. Other values, not present in the list, may be used as well. However, metadata that rely on the recommended values will have the highest degree of semantic

interoperability, i.e., the likelihood that such metadata will be understood by other end users or systems is highest"[30].
In order to maximize semantic interoperability, Eleonet extensions to LOM vocabularies have been undertaken by taking into consideration both Celebrate and Curriculum Online Vocabularies.

Table 3. Comparison between Curriculum Online and Celebrate vocabularies for 5.6 Educational. Context

Curriculum Online vocabulary	Celebrate
	Nursery school
Primary Education	Primary school
Secondary Education	Upper secondary school
	Lower secondary school
Higher Education	Post-secondary and higher education
University First Cycle	
University Second Cycle	
Technical School First Cycle	
Technical School Second Cycle	
Professional Formation	Professional development
Continuous Formation	Adult education / lifelong learning
Vocational Training	Vocational training
	Distance education
	School lib /documentation centers
	Educational administration;
	Educational policy
	Special education
	Other

As an example, table 3 illustrates the comparison between Celebrate and Curriculum Online vocabularies for *5.6. Educational. Context.* It can be noticed that while Curriculum Online vocabulary mainly focuses on school cycles and partly reflects UK national curricula, Celebrate provides a wider representation of educational contexts, going further with both the compulsory education system and a county-based approach to education.
According to Eleonet expected outcome, that is to build up a European catalogue of metadata referring to LOs produced in different countries on the basis of different national educational programs, it can be argued that in the case of *5.6. Educational. Context* Celebrate Vocabulary better fits the need of describing the European - and not the national - learning environment.

Table 4 illustrates another example of semantic interoperability analysis undertaken within Eleonet metadata survey, focusing on Celebrate and Curriculum Online vocabularies for LOM data element *5.2 Educational. Learning Resource Type.* As results from the table, in this case it's possible to map most of the values from one AP to the other and then extend Celebrate value lists – which enables a more precise classification of LOs types – just with the two Curriculum Online values which have no correspondence with it ("Open activity" and "Tool").

[30] IEEE LOM 2002, IEEE Standard for Learning Object Metadata, IEEE Standards Department, Institute of Electrical and Electronic Engineers, Inc. (2002). IEEE-SA Standard 1484.12.1-2002.

Table 4. Comparison between Curriculum Online and Celebrate vocabularies for 5.2 Educational. Learning Resource Type

Curriculum Online vocabulary	Vocabulary based on LOM and Celebrate
Drill and Practice	Exercise
	Educational game
Exploration	Simulation
	Experiment
Guides (tutorial)	Tutorial
Information resource	Information resource
Glossary	Glossary
Assessment	Self Assessment;
	Exam
	Questionnaire
	Problem statement
	Case study
	Lecture
Open Activity (Artistic projects and creative exercises)	
Tools	

4.3.2 Syntactic Interoperability

Beside semantic interoperability, a second form of interoperability playing an important role in Eleonet development is known as "technical" or "syntactic" interoperability.

This form of interoperability, which is concerned with the effective communication, storage and representation of metadata and other types of information at XML schema level can be achieved by referring to **IEEE - Standard for XML binding for Learning Object Metadata data model** as full metadata schema to be implemented.

This IEEE Standard defines a World Wide Web Consortium (W3C) Extensible
Markup Language (XML) Schema definition language binding of the learning object
metadata (LOM) data model thus providing XML developers with a specific language for the creation of LOM instances in XML and allowing for interoperability and exchange of LOM XML instances between various repositories.

Despite this effort in support of technical interoperability for the LOM, XML developers tend to simplify the LOM data model as it is implemented in databases thus creating difficulties in the communication between different IT systems.

These difficulties arise from the fact that systems based on "simplified" LOM data models are not able to reliably exchange and store metadata records that utilize particular parts --or even the whole-- of the LOM data model.

Given the importance of maintaining the full complexity of the LOM data model to achieve syntactical interoperability, the Eleonet system, through defining a simplified LOM metadata subset to be supplied by LOs producers, will implement the full LOM XML schema so that it can receive and retransmit any data compliant with the LOM data model.

5. Metadata for search and display

In order to provide a worthwhile service to final users, Eleonet LOM AP is to be built by taking into great account final users' information needs as well as their way of searching and browsing educational resources.
In other terms, a key principle driving the LOM application profiling activity consists of selecting LOM data elements carrying information which is expected to be relevant to users' searches and to effectively display LOs information on Eleonet catalogue pages.
For each information provided by the publisher, table 5 illustrates whether it could be used for[31]:

- *structured searches*: learning objects could be searched by specific criteria, such as by teaching subjects and keywords or by LO producers' names
- *full text searches*: the values of some elements, such as the title and the general description of LOs, could be used for full text searches
- *presentation to final users*: the values of some elements could be displayed to final users on a *full product information* web page; a subset of this information could also be provided as a *short presentation* of each LO on the web page of search results.

Nr.	Name	Description	Used for structured searches	Used for full text searches	Displayed to final users (Short-Presentation)	Displayed to final users Full product information page
1.1.2	**General. Identifier. Entry** (SCORM:M)	The value of the identifier within the identification or cataloging scheme that designates or identifies this learning object. A namespace specific string.				
1.2	**General. Title** (SCORM:M)	Name given to this learning object.				
1.3	**General. Language**	The language of the learning object.				
1.4	**General. Description** (SCORM:M)	A textual description of the content of this learning object				
1.5	**General. Keyword** (SCORM:M)	A keyword or phrase describing the topic of this learning object. **Note:** This field could carry the values which are not included into the thesaurus (i.e person names, names of literary or political movements, etc)				
2.1	**Life Cycle. Version** (SCORM:M)	The edition of this learning object.				
2.2	**Life Cycle. Status** (SCORM:M)	The completion status or condition of this learning object. Vocabulary (SCORM): -Draft -Final -Revised -Unavailable				

[31] For clarity purposes, table 5 doesn't show neither parents elements (that is, aggregate data element which don't carry any value) nor metadata that will be automatically provided by Eleonet system. In other terms, the table summarizes just the information which is to be directly provided by the LOs producer

2.3.1	**Life Cycle. Contribute. Role**	It should be recommended to describe at least the author and/or the publisher of the Learning Object				
2.3.2	**Life Cycle. Contribute. Entity**	The name of the author and /or the name of the publisher. **Note:** An alphabetic list of publishers should be provided for enabling the user to browse the resource by contributor.(i.e the "Search by supplier" in Curriculum Online)				
2.3.3	**Life Cycle. Date**	The date of the contribution				
4.1	**Technical. Format** (SCORM:M)	Technical datatype(s) of (all the components of) this learning object. Allowed values are - MIME types based on IANA registration (see RFC2048:1996) - or "non-digital"				
4.3	**Technical. Location**	The string that is used to access this Learning object**. (DOI) Note:** If used to specify the DOI string that resolves to the LO, this field must be considered mandatory (regardless of SCORM conformance requirements)				
5.2	**Educational. Learning Resource Type**	Specific kind of learning object. The most dominant kind shall be first. Vocabulary based on LOM and Celebrate: self assessment exercise experiment lecture problem statement simulation exam/questionnaire case study tutorial Educational game questionnaire information resource glossary Open Activity Tools **Note:** for a greater level of interoperability with Curriculum Online resource, the values "Open Activity" and "Tools" have been added to the vocabulary				
5.6	**Educational. Context**	The principal environment within which the learning and use of this learning object is intended to take place. Vocabulary based on CELE BRATE; This vocabulary will be compared with Curriculum Online vocabulary for possible extensions.				
5.7	**Educational. Typical Age Range**	Age of the typical intended user.				

6.1	**Rights. Cost** (SCORM:M)	Whether use of this learning object requires payment. Vocabulary (SCORM): -Yes -No **To be displayed as:** If 6.1 is set to "yes", the value "priced resource" could be displayed. If 6.1 is set to "no", the value "free resource" could be displayed. **Note:** in the search mask, the user could specify to search only for free vs. priced resources				
6.2	**Rights. Copyright and Other Restrictions** (SCORM:M)	Whether copyright or other restrictions apply to the use of this learning object. Vocabulary (SCORM): -Yes -No **Note:** if the value is set to yes, then it will display the text from 6.3 Rights. Description				
6.3	**Rights. Description**	Comments on the conditions of use of this learning object. **Note** :Curriculum Online uses this field for carrying the copyright owner and date.				
9.2.2.2	**Classification. TaxonPath. Taxon. Entry**	A specific entry in a classification scheme; (i.e Teaching subjects) **Note:** in order to allow users to search resources by subject, an agreed subject scheme should be defined.				
9.4	**Classification. Keywords**	If a thesaurus is implemented as indexing system, keywords are formally "descriptors" extracted from the thesaurus.				

6. Conclusions

The ultimate aim of this survey was to ensure that the metadata schema utilised by ELEONET is rich enough to provide an adequate description of Learning Objects for several different purposes while still ensuring the maximum level of interoperability with other systems. After considering several major projects and implementations concerning learning objects, the study concluded that LOM was the most appropriate standard. However, as there are already numerous Application Profiles (APs) which aim to comply with this standard, careful analysis of these APs was required, as it became evident that not all APs necessarily comply fully with the SCORM standard, or else have been designed to meet differing requirements from those of ELEONET (e.g. to meet the needs of a specific community or to address specific functions). Consequently, a subset of mandatory data elements has been developed for use by the ELEONET implementation according to the SCORM Metadata AP Requirements; it is believed these should enable DOI registrants to participate in ELEONET by supplying a minimum set of mandatory information without excessive effort. Afterwards, in addiction to LOM minimum metadata subset for DOI registration, further optional data elements have been selected in compliance with the most widespread LOM application profiles as to enable publishers to provide a more complete description of educational resources and improve their searchability.

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