PHOTODENTRO LOR, THE GREEK NATIONAL LEARNING OBJECT REPOSITORY[1]

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Abstract

This paper presents *Photodentro LOR*, the Greek National Learning Object Repository (LOR) for primary and secondary education. *Photodentro LOR* hosts open learning objects: small, semantically and functionally autonomous, reusable, open educational resources, tagged with educational metadata. It is targeted to teachers and pupils and it constitutes a core part of the Greek Ministry of Education digital infrastructure for educational content for schools. The paper also discusses issues to be taken into account when designing a National Learning Object Repository for schools, and provides an overview of the *Photodentro LOR* design and implementation, including semantic interoperability and metadata issues, technical decisions, and workflows for content population. The big picture of the infrastructure that includes the Photodentro National Educational Content Aggregator is also given.

Keywords: learning object repository (LOR), learning objects, national repositories, open educational resources (OER), metadata, e-textbooks, national digital educational content strategy, DSpace

1   INTRODUCTION

Digital educational content is an increasingly important part of *National Digital Educational Policies*. The creation and effective use of digital learning resources and the development and establishment of content-based online services for schools constitute key pillars in many National Initiatives for the integration of ICT in school education [1]

Over the last few years there is a growing interest in the use of *learning objects* as digital resources for learning. Multiple definitions have evolved to describe learning object. A widely accepted one is that of Wiley: "a learning object is any digital resource that can be reused to support learning. The term "learning objects" generally applies to educational materials designed and created in small chunks for the purpose of maximizing the number of learning situations in which the resource can be utilized" [2]. Chiappe defined learning object as:"A digital self-contained and reusable entity, with a clear educational purpose, with at least three internal and editable components: content, learning activities and elements of context. The learning objects must have an external structure of information to facilitate their identification, storage and retrieval: the metadata" [3].

A *Learning Object Repository (LOR)* is an on-line digital library of searchable learning objects that have been catalogued for educational purposes, along with a set of management, search and access mechanisms. A LOR stores learning objects and their metadata. Metadata allow the object to be indexed, making retrieval and reusing of learning material technologically easier. LORs implement a metadata standard to support semantic interoperability. Neven and Duval in [4] have presented the nature of repositories that contain learning objects and surveyed existing LORs, comparing their features and architecture; as explained "the metadata scheme of LORs is based on the IEEE LOM specifications [5] through a process that is typically referred to as an "Application Profile"". A large number of Learning Object Repositories have been established worldwide. The majority of them are targeted to Higher Education e.g. MERLOT [6] hosting mainly journal articles, tutorials, courses, and video lectures; examples of LORs targeting teachers and schools include LeMill (lemill.net) and Learning Resource Exchange (LRE) for Schools [7].

Building *National Learning Repositories* has recently become a common strategy, particularly in European countries. Examples include NDLR, the National Digital Learning Repository of Ireland [8] and SWITCH, the National Digital Learning Repository of Switzerland [9]. For primary and secondary education (K-12) in particular, National Learning Repositories have gained significant growth, since, in order to meet the requirements of national curricula goals, culture, and language, the development of learning resources happens in most cases at a National Level.

Analyzing the outcomes of a repository review conducted in the context of the ODS project [10], we can conclude that National Learning Repositories for primary and secondary education share common characteristics: they generally host resources that support the national curricula; in most cases they serve as the central point of access to learning resources for schools, particularly in countries with centralized educational systems; they are usually built in the context of national initiatives and programs aiming at the introduction of ICT in education; they are funded by local, national, or EU funds, and are usually supported by Ministries of Education (MoE) or local authorities. In most cases, they have been developed and are supported by the technical partner(s) of MoEs, in collaboration with pedagogical institutes and educational authorities in each country. Examples include: the Austrian repository for schools, Bildungspool [11], the Croatian national school repository "CARNet School Portal" [12], and the Bulgarian National Educational Repositories "Resursi.e-edu.bg" and "Znam.bg". In terms of their content type, national learning repositories either focus on user-generated content, providing thus a space for teachers to share learning resources, such as KlasCement portal [13], or on reviewed or certified resources, serving as the official space for distributing digital content to schools. It is also often the case that national repositories "come in couples" with educational platforms.

This paper introduces and presents "*Photodentro LOR*", the Greek National Learning Object Repository for primary and secondary education. The Greek National Policy for digital educational content and the Greek "Digital School" national initiative are presented to set the context. Issues that should be taken into account when designing a National Learning Object Repository for schools are discussed. The various aspects of *Photodentro LOR* design and implementation are described, including semantic interoperability and metadata support, technical decisions, and roles and workflows for content population. Finally, an overview of the Photodentro Federated Architecture that reflects the big picture of the infrastructure is given.

2 DESIGNING THE GREEK NATIONAL LEARNING OBJECT REPOSITORY FOR SCHOOLS

2.1 Lessons learned from the first period of educational content development

Large scale projects implemented in Greece during the past two decades introduced digital literacy in the school community and created a "critical mass" of teachers that utilize ICT in their school activities. During this first period, a large number of educational software products and learning resources for school education have been developed within various national initiatives. Lessons learned included: (a) the development of quality digital learning resources and software for school education is a very expensive process. Among others, it requires collaboration of experts from different domains, including personnel with pedagogical knowledge, technical skills, teaching experience, and expertise in educational and administrative issues; (b) content development for school education usually happens at a national (or local) level and at a national language in order to meet the needs of national curricula. However, non-widely used languages, such as Greek, limit content's use within borders, making it difficult for content creators to recover their initial investment; (c) large units of educational content such as integrated multimedia applications, learning scenarios, and courses are sensitive to curriculum changes and they need significant adaptation to be reused in different educational contexts; (d) digital content can become obsolete very quickly as technology is changing rapidly, causing software and hardware incompatibility issues; (e) copyright issues and unclear licensing schemes have been highlighted by teachers as key factors for not utilizing learning resources.

2.2 The Greek National Policy for Digital Educational Content

Digital educational content is a key priority of the Greek National Digital Educational Policy for primary and secondary education, which is reflected in the design of the national programs for the integration of ICT in school education. In-service teacher training and the development and operation of computational and networking infrastructure and services for schools, that include a national-level

school network, school labs, e-classrooms and interactive teaching systems, are the other two pillars of the national policy, both strongly linked with the provision and exploitation of digital content.

Following the directions of the 2020 digital agenda of Europe and the international trends, and taking into account the recent experiences and lessons learned described above, the key action lines of the Greek National Policy for Digital Educational Content are:

a) Focus on the creation of reusable units of learning; b) Promote Open Educational Resources (OERs); c) Promote re-using, remixing, and re-purposing of existing digital learning resources; d) Improve digital infrastructure to facilitate search, retrieval, access and utilization of digital learning resources for all (teachers, pupils, parents, everyone); e) Promote the active role of teachers and pupils in the creation, documentation and evaluation of digital learning resources.

2.3 The "Digital School" Greek Initiative for Digital Educational Content

"Digital School" is a large scale national initiative of the Greek Ministry of Education (MoE) for the modernization of school education in Greece. It includes a series of actions organized into five key areas: Infrastructure, Digital Educational Content, Teachers Training, electronic Management of Education, and Support actions.

The *"Digital School Platform, Interactive Books, and Learning Object Repository"* [2] is a flagship project within the Digital School initiative for digital educational content for schools (dschool.edu.gr). It has a five (5) years duration (2010-2015) and a total budget of 9.5 million Euro. Since its beginning it has involved more than 200 teachers, pedagogical and domain experts, and academic professors, and around 80 engineers and technical personnel. Key actions of the project concern:

Interactive e-textbooks & learning resources

- Creation of *interactive e-textbooks* for all school disciplines in primary and secondary education*:* All school textbooks are made available online in digital editable format (html), and are being enriched with click-and-play interactive learning resources.

- Development of a large number of *open, reusable learning objects* covering a wide spectrum of areas and educational objectives of primary and secondary education; these are initially designed and developed for the purpose of enriching the online versions of e-textbooks.

- Design, development and operation of the *Interactive Books* portal, serving as the official portal of the Greek MoE for hosting and distributing the digital school textbooks (*ebooks.edu.gr*)

The National Digital Repository Infrastructure for Learning Resources for schools (Photodentro)

- Design, development and operation of the *Greek National Digital Learning Repositories* for hosting, organizing, and distributing learning resources for schools: *Photodentro LOR* is the cornerstone of the infrastructure, hosting learning objects *(photodentro.edu.gr/lor)*. The Photodentro Repository ecosystem also includes *Photodentro EduVideo (photodentro.edu.gr/video)*, hosting short length educational videos suitable for in-class use, and *Photodentro UGC* (*photodentro.edu.gr/ugc*), hosting learning resources developed by teachers, thus representing the user-generated branch of the ecosystem.

- Design, development and operation of the *Greek National Educational Content Aggregator Photodentro*, a national service for harvesting and accumulating educational metadata from various repositories and collections (museums, libraries, audiovisual archives, etc.), thus serving as the central access point to learning resources for schools in Greece (*photodentro.edu.gr*)

- Content population, that includes selection, uploading, metadata authoring, validation, and publishing of digital learning resources to the national repositories, as well as harvesting, selection, and metadata enrichment of resources hosted in external repositories.

The Greek Digital Educational Platform (e-me)

- Design, development and operation of the *Greek Digital Educational Platform for all schools, pupils and teachers* in primary and secondary education: The *e-me* platform –currently under development- aims at providing a safe working space for pupils and teachers, with a modern and intuitive environment, to share their content, connect, communicate and collaborate with mates, publish their work, download useful apps, and access and exploit efficiently learning resources.

2.4 Decisions when designing a National Learning Repository for schools

Several factors must be considered when establishing a national learning repository for primary and secondary education:

What is the main target audience of the repository? For a school repository, the decision mainly concerns whether the repository is targeted to teachers or to pupils. Most of the national learning repositories are targeted to teachers; although many resources can be used directly by pupils as well, browsing and search interfaces as well as metadata describing the resources are mostly designed having teachers in mind. Designing for pupils implies, for instance, that navigation to resources will be based on a thematic taxonomy that follows learners' perception of knowledge organization, i.e. school disciplines and concepts that pupils are familiar with. This may differ significantly from a scientific taxonomy for classifying resources in the specific domain.

What types of learning resources will the repository host? This is an important decision for a repository as it determines among others the specifications for the repository's metadata Application Profile. For a national learning repository the decision should take into account what has been done so far at a national level i.e. what types of digital learning resources are there (e.g. learning scenarios, educational software, videos, other), the national strategy regarding the educational content (e.g. a strategy promoting Open, Reusable Learning Objects) as well as the current and planned initiatives for digital content for schools.

What is the main need that the repository should address? This decision may determine the nature of the repository, the user roles as well as its workflows and operations. A repository that will serve as a national portal for delivering official (certified or not) learning resources to schools implies authorized users in the whole content lifecycle, potential involvement of national authorities in the workflow, need for massive upload of learning objects, etc. If the need is to provide an environment for teachers in order to share their own resources, the focus should be on social networking functionality, moderation issues, and on flexible workflows to support new trends.

In all cases, when designing a National Learning Repository it is important to:

1. Implement the vision of the National Strategy regarding educational content and services.

2. Capitalize on previous experience gained from country-wise initiatives, regarding users' experience, outcomes of previous projects, existing infrastructure and services etc.

3. Listen to the users (and try to satisfy user needs and demands) and take into account the "culture" of educational communities in each country.

3 INTRODUCING PHOTODENTRO LOR

3.1 "Photodentro LOR" in a nutshell

Photodentro LOR is the Greek National Learning Object Repository (LOR) for primary and secondary education. It hosts reusable learning objects (small, self-contained reusable units of learning). It is open to everyone, pupils, teachers, parents, as well as anybody else interested. The URL for accessing *Photodentro LOR* is http://photodentro.edu.gr/lor.

The design and implementation of *Photodentro LOR* started in 2011 and its first version was established online on March 2012. It currently hosts around 3,800 learning objects, organized in thematic or other collections. The majority of these objects have been developed during the past three years by around 120 qualified teachers in the context of enriching Greek textbooks with digital interactive resources. In an attempt to make the most out of previous publicly funded projects, the next population phase of *Photodentro LOR* focuses on open learning objects that can be extracted from existing educational software and learning scenarios developed during the last decade.

Photodentro LOR implements the Greek National Strategy for educational content, which –among others- promotes the use of open educational resources (OER) for schools. All learning resources are freely available to everyone under the Creative Commons' Attribution-NonCommercial-ShareAlike license. *Photodentro LOR* supports browsing, free text search, and faceted search, allowing users to narrow search results by applying multiple filters, such as learning resources type, educational context, etc. It fully supports the IEEE LOM [5] specifications. Its implementation is based on DSpace [14], an open source platform for building digital repositories. It provides an Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) target [15].

Figure 1: The *Photodentro LOR* home page

Its name has been carefully selected to convey the message of what *Photodentro* is: a repository that contains "knowledge"; that is alive and grows like trees (in contrary to archives); and it is Greek. The word "Photodentro" means "Light Tree", and it is taken from the title of the poetry collection "The Light Tree and the Fourteenth Beauty" (1971) of the greek Nobel prize winner Odysseas Elytis.

3.2 Photodentro LOR Learning Objects (LOs)

3.2.1 From the digital resources of e-textbooks to reusable learning objects

Teachers and pupils are very familiar with printed textbooks. It was therefore a central decision for the Greek MoE to use the enriched e-textbooks as a vehicle for smooth transition towards familiarization of teachers with digital learning resources. In the centralized Greek educational system, where there is one official textbook for each discipline, this decision could be efficiently materialized.

The process of enriching greek school textbooks with interactive learning material has triggered the development of some thousands of learning resources ([16][17][18][19]). Linking learning resources within e-textbooks' html online version was considered -and proved to be- a good, alternative approach for associating resources with learning goals of the curriculum. Interactive e-texbooks offered a familiar browsing interface for teachers to navigate through these learning resources.

However, although this approach has been highly appreciated, there was an initial great concern about the efficiency of the investment, mainly regarding reusability. A key question was "what will happen when textbooks change, or, when a concept that is currently taught, for instance, in 2nd grade of high school, will next year be taught in 3rd grade. Promoting and putting all efforts on developing *reusable* learning objects, as well as developing a national learning object repository that will store, organize, describe, and maintain them, has been a strategic decision in order to achieve sustainability. *Photodentro LOR* was designed and developed to mainly serve this goal.

Towards this end, guidelines to the teams of qualified teachers who have been developing these resources included: 1) Design learning resources having reusability in mind; 2) Develop small, self-contained, semantically and functionally autonomous units of learning; 3) Decontextualize existing

resources from the e-textbook context for which they were initially developed, to make them reusable in different contexts. Describing them with metadata will help their re-contextualization.

3.2.2 Specifying Photodentro LOR resources

Among the various definitions of learning objects, that of Chiappe [9] seemed to serve best the concept of *Photodentro LOR* learning object. Adopting and adapting it, a learning object in *Photodentro LOR* can be "any digital resource that 1) has as a clear educational purpose; 2) is reusable, i.e. it can be used in multiple contexts for multiple purposes; and 3) is semantically and functionally self-contained. In addition, *Photodentro LOR* specifications restrict learning objects to those which 4) serve goals of the national curricula of primary and secondary education; 5) are available on-line; and 6) are provided under a cost-free license for educational purposes.

The transition from designing digital resources for e-textbook enrichment to that of designing learning objects was not straightforward, even for ICT-experienced teachers. The concept of reusability and the appropriate granularity level of a learning object proved to be the most difficult ones. Issues such as "when a picture can be considered as a learning object", "how to extract semantically and functionally self-contained objects from more composite ones", or "how the aggregation level (granularity) of learning objects affects their reusability" have been extensively discussed in this context.

3.3 Photodentro LOR communities, collections, and learning objects

Photodentro LOR resources are organized into collections; collections are grouped into larger communities; a community represents content contributors working within the same framework or for the same goal. The "Digital School" community was the first one in *Photodentro LOR*. It was set up for the purposes of digital textbook enrichment; it consists of around 120 qualified teachers in ten (10) domain-specific workgroups, each one operating under the supervision of a coordinator (academic with significant domain and pedagogical expertise).
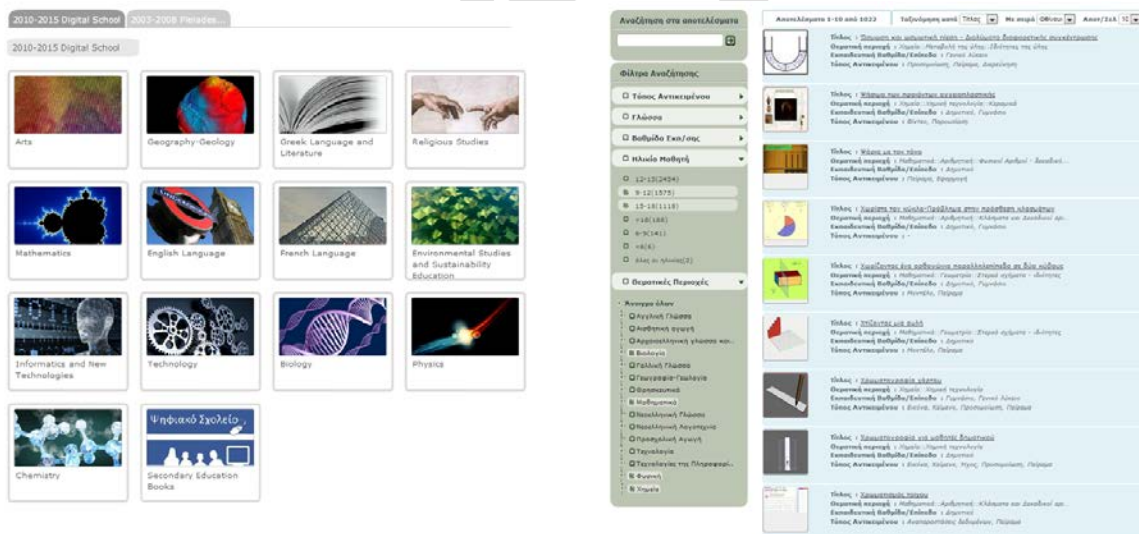

Figure 2: Photodentro LOR Digital School Collections and learning objects

Since 2011, the "Digital School" community has developed and maintained thirteen collections of learning objects, including Mathematics, Geography-Geology, Biology, Physics, Chemistry, English, French, Informatics, Technology, Religious Education, and Aesthetic Education.

So far, collections have been populated with 3,800 learning objects selected from a total of 6,500 resources developed for textbook enrichment ([16][17][18][19]) so that they conform to the *Photodentro LOR* specifications for learning objects. All objects are "click-and-play", i.e. can be directly reproduced in web browsers. Regarding their type, they include explorations and inquiry-oriented activities, dynamic simulations and experiments, educational games, presentations, interactive exercises, interactive maps as well as simple learning assets. Figure 3 gives a quantitative view of these resources.
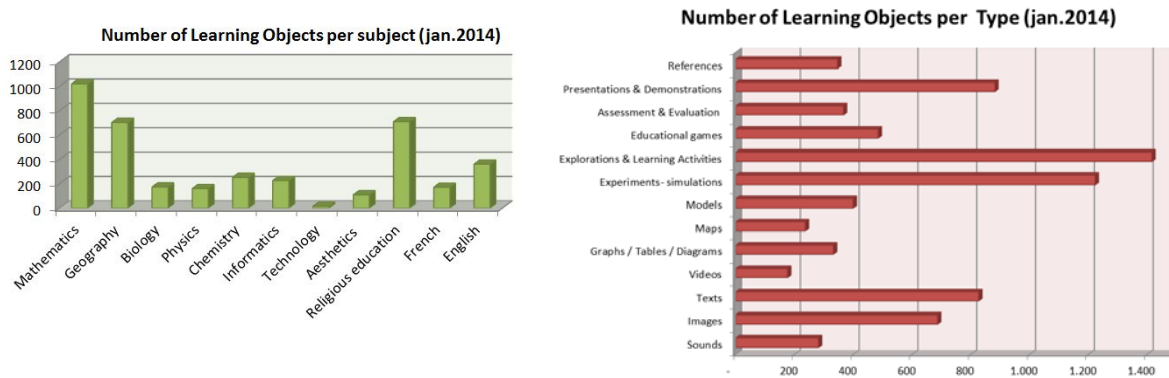
Figure 3: Photodentro LOR Numbers of Learning Objects per subject and type

3.4 Browsing, filtering, and searching resources in Photodentro LOR

Photodentro LOR supports browsing, free text search, and faceted search to enable users find learning resources. *Browsing by collections* enables users to navigate through the hierarchy of *Photodentro LOR's* collections and sub-collections and explore the learning objects in each collection (Figure 2). When *browsing by subject,* users go through the hierarchy of terms in the *Photodentro LOR* thematic classification taxonomy (see §4.1.2); objects classified at each level and below are listed. As shown in Figure 4, information visualization techniques have been used to facilitate *browsing by subject* that is considered a flexible and effective way to find objects in learning object repositories [20]. *Browsing by Learning Resource Type* is similarly supported.
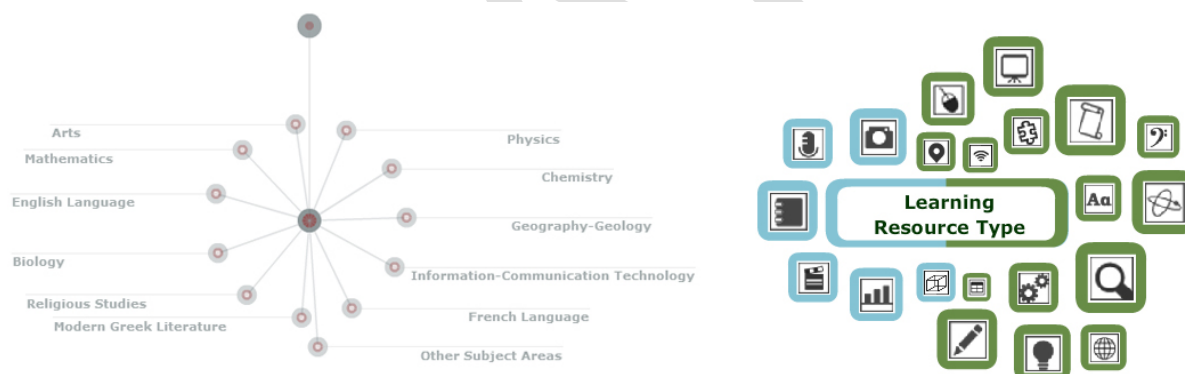

Figure 4: Photodentro LOR browsing by subject and by learning resource type

Users can also explore *Photodentro LOR* by applying multiple filters to narrow search results (faceted search, see Figure 2). Filters are selected elements of the *Photodentro LOR* LOM Application Profile (AP) described below, such as educational context, age of students, learning resource type, thematic classification; values are taken from the relevant controlled vocabularies.

4 PHOTODENTRO LOR IMPLEMENTATION

4.1 Semantic Interoperability & Metadata Support

4.1.1 The Photodentro LOR IEEE LOM Application Profile

As a means of describing and indexing its learning resources, *Photodentro LOR* supports metadata based on the IEEE Learning Object Metadata (LOM) specification [5]. A IEEE LOM Application Profile (AP) was built, used and evaluated in order to support *Photodentro LOR* needs and to enable effective search and retrieval of learning objects. The design of the *Photodentro LOR* LOM AP took into account the various factors discussed in §2.4 regarding the target audience, the existing collections and types of resources, the expressed user needs, as well as the overall vision for the *Photodentro*

LOR as a national repository of open learning resources for school education. This process involved experts in relevant pedagogical and technological issues and metadata standards -among them, a member of the national organization of standardization in Greece. Controlled vocabularies of the *Photodentro LOR* LOM AP are based on the Learning Resource Exchange (LRE) LOM AP [21].

4.1.2 Thematic Classification Taxonomies

Browsing by Subject is a strong user requirement for a school learning object repository. In order to support it, a classification system was required for categorizing learning objects according to their thematic area, topic, or concept they represent. A simple taxonomic system of classification, that is composed of a hierarchy of terms, was considered most appropriate to facilitate browsing; this conclusion was also supported by our previous experience of using a non-hierarchical scheme (the multilingual EUN LRE Thesaurus [21]) to classify and support browsing to video resources in the edutube*plus* repository [22], which proved complicated, particularly for pupils in primary education.

Towards this end, thematic classification taxonomies were designed to satisfy the following principles: 1) allow classification of resources according to pupils' perception of how learning resources are organized in such a repository; 2) keep the classification simple, by restricting hierarchical levels up to three, and a maximum of 15 terms in each level; 3) comply with the Greek national curriculum for primary and secondary education in terms of subjects, topics and concepts. Since there was not any taxonomy in Greek covering the above requirements, ten (10) new, three-level thematic classification taxonomies have been developed covering almost all school disciplines. The restrictions in taxonomy depth and breadth have been reported as interesting challenges by the taxonomy development teams. Taxonomy terms have been also used to index learning resources, improving search.

4.2 Using DSpace as Photodentro LOR digital repository system

Photodentro LOR is based on DSpace [14], a widely used digital repository management system for building and maintaining digital repositories. DSpace is open source and freely available, which complied with the strategic decision to base *Photodentro LOR* on open source technologies. Although DSpace is very popular worldwide, examples of using DSpace as Learning Object Repository (LOR) are limited (Jorum, a JISC funded service in UK is an example). The decision of using DSpace was taken in 2010, after an extensive study of repository building platforms. DSpace uses Dublin Core as its base metadata scheme; hence DSpace support for building LOM application profiles was a critical factor. The underlying technologies and the existence of a solid community of DSpace users and developers were also important. Significant extensions and customization were made in DSpace in order to meet the requirements of *Photodentro LOR*, including: implementation of the *Photodentro LOR* LOM AP, development of a graphical interface to improve user experience while browsing and searching, and implementation of custom workflows and forms for metadata authoring process, as the sequential workflow of filling out metadata forms provided by DSpace was not considered efficient.

5 CONTENT POPULATION IN PHOTODENTRO LOR

5.1 User Roles & Work Flow

Populating the *Photodentro LOR* with learning objects is performed by authorized users. The process involves content uploaders, metadata authors, metadata validators, and the collection administrator. Figure 5 gives an overview of the process and work flow.

Metadata authoring and validation process of the *Photodentro LOR* learning objects has been performed by the "Digital School" community of experienced teachers (described in section 3.3), being in most cases the creators of learning objects. The coordinators of the domain-specific workgroups hold the role of collection administrator of the corresponding collection(s). For each collection 1-3 validators have been assigned. The main language of metadata is Greek.
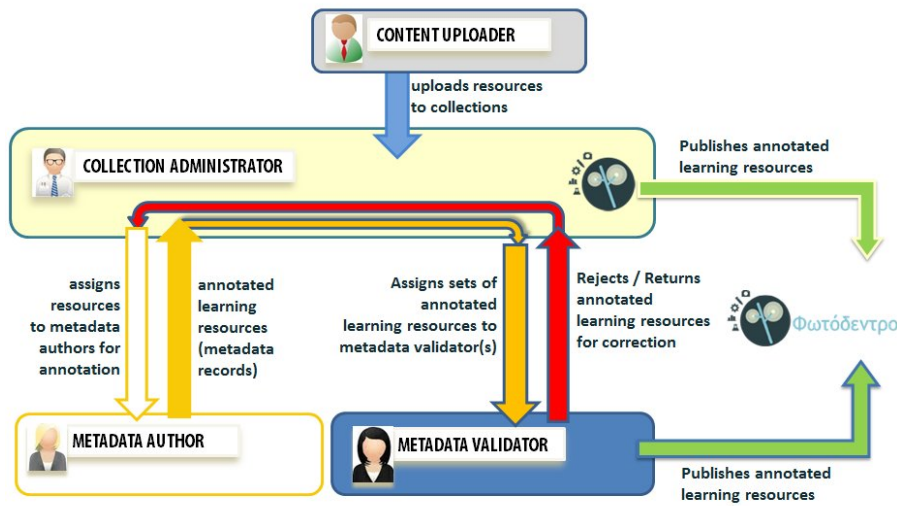
Figure 5: Photodentro LOR content population process and work flow – An overview

5.2   Photodentro LOR Metadata Authoring Environment

A form-based metadata authoring environment has been developed in DSpace to support authorized users in the process of editing metadata according to the *Photodentro LOR* LOM AP (Figure 6). Metadata elements are organized into four (4) forms to support non-sequential workflows and the different groups that are usually involved in the metadata authoring process for institutional repositories: personnel with pedagogical knowledge or teaching expertise, who can work with the general and educational metadata forms to describe resources, suggest their educational use, and classify them according to curriculum goals and educational contexts; technical personnel, can who can edit the technical metadata form, describing technical requirements of learning objects, and personnel experienced in copyright and licensing schemes, editing the legal metadata form.
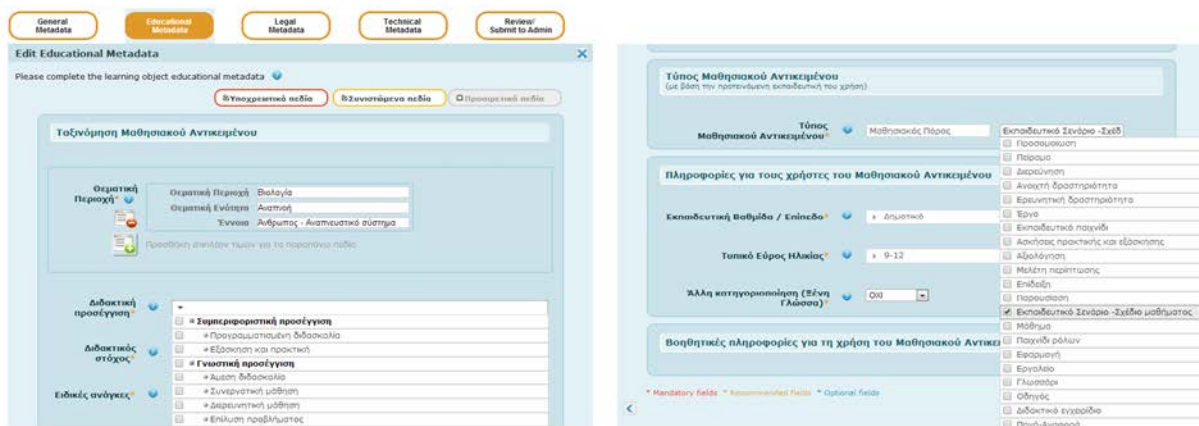

Figure 6: Photodentro LOR form-based metadata authoring environment

6   THE BIG PICTURE: PHOTODENTRO FEDERATED ARCHITECTURE & FUTURE WORK

Photodentro LOR represents a large scale effort at a national level; it is however only one component of the Photodentro infrastructure that is being implemented to support digital learning resources in primary and secondary education in Greece. Figure 7 gives an overview of the Photodentro Federated Architecture that reflects the "big picture".

A multi-layer and service oriented architecture has been designed for the Photodentro infrastructure, which includes four layers: (a) the Photodentro Web portal that provides access to the learning

resources in a uniform way, (b) the Aggregation Layer, where metadata harvesting from the repositories where resources are hosted, metadata validation, and metadata storing take place, (c) the Collection Management Layer, that manages the collections that are to be aggregated and provides an environment for their metadata enrichment. *Photodentro LOR* is the first repository of this layer. *Photodentro LOR* has been cloned and customized accordingly to support educational video resources and user-generated content, resulting in the Photodentro educational repository ecosystem. And (d) the Ingestion Layer, that processes metadata from various external sources (museums, libraries, audiovisual archives, etc.). MINT (Metadata Interoperability Services) is used for gathering metadata from external repositories as well as for facilitating the metadata mapping process.
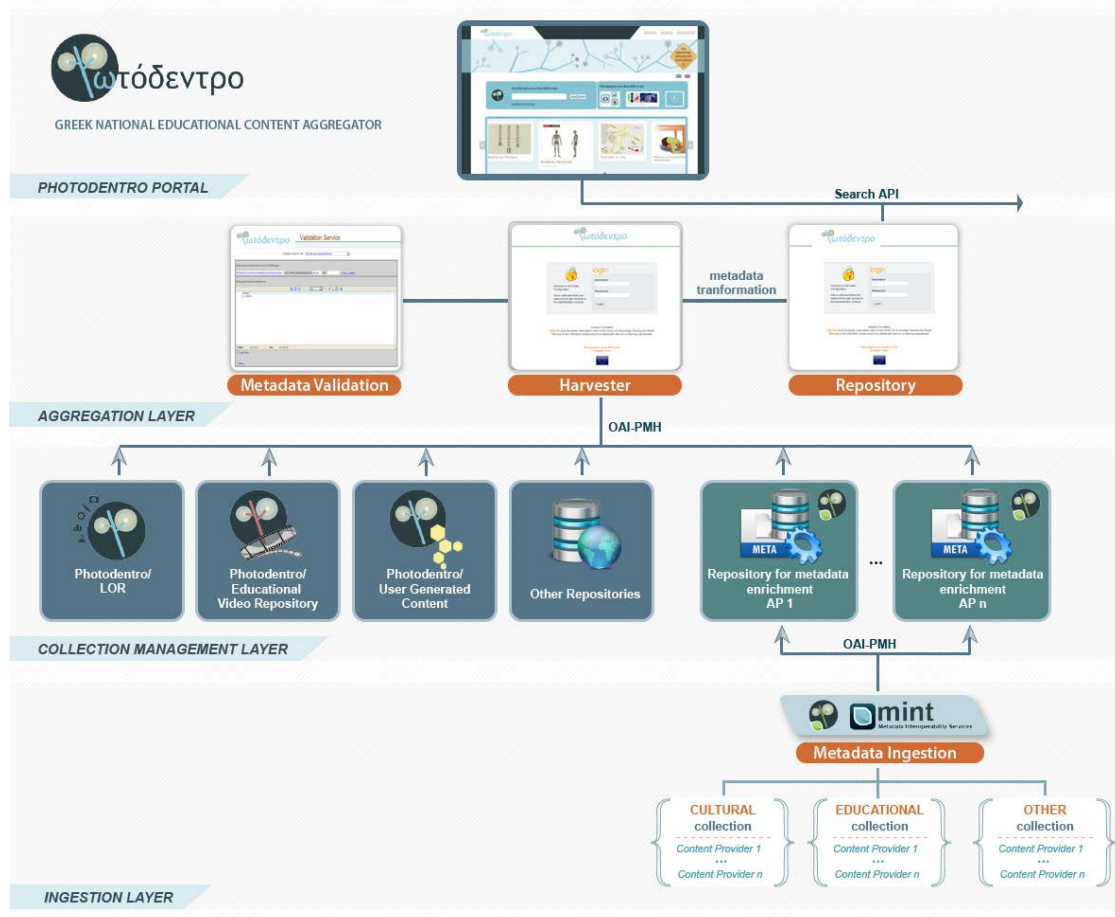

Figure 7: Photodentro Federated Architecture for Learning Resources

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