Educational Resources as Social Objects in Semantic Social Networks

Eleni Kaldoudi[1] , Nikolas Dovrolis[1], Daniela Giordano[2] and Stefan Dietze[3],

[1] School of Medicine, Democritus University of Thrace, Alexandroupoli, Greece
kaldoudi@med.duth.gr, ndovroli@alex.duth.gr
[2] University of Catania, Dipartimento di Ingegneria Elettrica, Elettronica e Informatica, Viale A. Doria 6, 95125, Catania, Italy
dgiordan@diit.unict.it
[3] The Knowledge Media Institute, The Open University, MK7 6AA, Milton Keynes, UK.
s.dietze@open.ac.uk

Abstract. Educational content is often shared among different educators and is enriched, adapted and in general repurposed so that it can be re-used in different contexts. This paper exploits the various aspects of object-centered sociality that the educational resource can manifest in a participatory virtual community of authors and learners. These social facets include: (a) the obvious connections via common tags; (b) connections based on collective usage and other related interaction of human users; (c) social connections based on the inheritance as realized via educational content repurposing; (d) semantic connections and similarities of accompanying metadata. The concept of exploiting the various aspects of educational resources as social objects is shown in the implementation of the MetaMorphosis+ social network for educational resource sharing in health sciences.

Keywords: educational resource, social networking, semantic technologies, Linked Open Data.

1 Introduction

During the past ten years we have experienced the realization of the so-called "information society", characterized by mass information seeking and based on the distribution, mainly via the internet, of pre-defined and standardized digital data. Current and emerging trends in information systems and communication services mark the shift towards a "knowledge society", that is, a society based on knowledge as a value. Thus, educational resources (in the broad sense) become a central issue in our society. This paper exploits the social aspect of educational resources within a participatory virtual community of authors and learners as realized via the MetaMorphosis+ environment for sharing educational resources in medical education.

This work is conducted partly within the mEducator project, an EU funded best practice network (under the eContentPlus2008 programme, Contract Nr: ECP

2008 EDU 418006) with the aim to implement and critically evaluate existing standards and reference models in the field of e-learning in order to enable specialized state-of-the-art medical educational content to be discovered, retrieved, shared and re-used across European higher academic institutions. The following sections discuss some of the different facets of the educational object sociality, including (a) the obvious connections via common tags; (b) connections based on collective usage and other related interaction of human users; (c) social connections based on the inheritance as realized via educational content repurposing; (d) semantic connections and similarities of accompanying metadata. Then, the concept of exploiting the various aspects of educational resources as social objects is shown in the implementation of the MetaMorphosis+ semantic social network [1].

2 Educational Content as a Social Object

The social Web, or Web 2.0 [2], has become an important trend during the last few years. Among the prominent social web tools, social networking websites focus on creating online communities of individuals who publish their content and activities while exploring others content and activities, thus creating virtual on-line social groups and associations.

This communication paradigm has been taken up by the community of researchers and academics and nowadays there is a thriving number of social networks dedicated to science and professional relations. Most of these virtual communities provide a way for researchers to create and populate their online profiles and share their work with others. Recently the term object-centered sociality was introduced [3] to describe the fact that strong social relationships are built mainly when individuals are grouped together around a shared object that mediates the ties between them. Therefore, we can assume that each content item on a social network site can be a source of social connectivity, catalyzing social networking in virtual spaces. This new approach to sociality has drawn attention, and current state-of-the-art research in the area involves various ways to exploit object-oriented sociality to the benefit of the community. For example, a semantic tag model has been recently introduced for representing tag data in the form of reusable constructs at a semantic level in order to share tag metadata across heterogeneous social networking sites [4]. A similar work proposes to use existing information on Web 2.0 and convert it to RDF which can be used as a flexible model for describing and integrating data [5],[6].

In this paper we take a different novel view about merging semantic technologies with the social web in order to enhance object-centered sociality and data integration. Here the social object is the educational resource. In our work, we view and exploit their 'social aspects' of educational resources in a variety of different ways as described below.

2.1 Building a Social Profile for Educational Resources

The most straightforward social dimension of an educational resource as a social object in a network can be realized in the conventional way of connections among profile tags. This requires a standardized metadata set to describe concisely an educational resource and thus create its social profile. Standardizing metadata for describing digital educational resources constitutes one of the main research topics in the e-learning community. Currently, the IEEE LOM (Learning Object Metadata) XML scheme seems the most prominent standard for describing learning objects [7] as it derives from a number of related standardization initiatives. LOM defines a wide range of metadata to classify and characterize learning resources, which include: overall description (cataloguing, annotations, and associations and relationships with other learning resources), technical data (file size, format, installation/usage descriptions), educational data (educational purpose, learning objectives, classification), and management data (intellectual property rights). However, there are no generally accepted conventions for properly describing learning objectives or the learning context, and although attempts have been made (such CLEO, and Educational Markup Languages) these only capture some of the semantics; thus more complex models are needed [8]. Thus, different communities give different meanings and use different descriptions (e.g. extensions/alterations to LOM, such as Healthcare LOM, etc), really breaking down the notion of the standard. Whereas the above difficulties relate to issues of relevance, semantics and usability, a more severe critique of learning object metadata standards [9] points out that the assumption implied in the current ways of describing an educational resource is that “information equates learning”.

Since metadata currently only describes simplified technical and structural characteristics of learning objects, In order to put emphasis on the educational nature and context of a resource (as opposed to its technical integration in the digital world) one had to resort towards metatags that describe the nature of the learning activities in relation to the knowledge states that may result, or the thinking processes stimulated by the activities entailed by the resource. This approach is taken by the mEducator consortium in their recent proposal of a metadata scheme to capture pedagogical aspects of a learning resource as well as patterns of activity (e.g. repurposing episodes, but not only). The mEducator metadata scheme [10] includes a number of fields addressing different aspects of the educational resource: (a) general fields: resource title, unique identifier, URL, URN, intellectual property rights clearance/license, quality stamp (if any); (b) fields related to a general resource description: resource authors, creation date, citation (i.e. how the resource should be formally cited), keywords, content description, technical description (including any technical requirements to access and use the resource); (c) fields related to the educational aspect of the resource: educational context (for which the resource is intended), teaching/using instructions, educational objectives, expected learning outcomes, suggested assessment methods, educational prerequisites; (d) fields related to classification/taxonomy information: resource language, type, discipline, discipline subspecialty, educational level; and (e) fields addressing repurposing: resource parents, repurposing context, repurposing description.

These user generated description metadata, when treated as social tags, create a complex and dynamic organization of educational resources in a similar fashion as in any conventional social network, thus realizing the resources' social network.

2.2 Resource Sociality based on Collective Usage Interaction

Educational resources are accessed, used, shared, repurposed, and also rated, commented upon, and can be organized in a number of user specified ways in collections. Capturing and sharing information about the attention that users spend on resources in specific contexts can provide a different aspect of sociality based on the personal views and mental models of the users. This way one can build the profile of a resource as it appears to the external user, as opposed to the profile of the resource according to the view of its creator, as depicted in the description metadata.

The perspective and attention is normally captured via recording contextual attention metadata [11]. This includes data about the users' attention and activities that relate both to semantically rich actions on and interactions with educational content items as well as data on indirect interactions amongst content items. Additionally, basic interaction metadata can also be considered which includes all other basic user-system interactions that provide some kind of basic attention information (not necessarily semantically and contextually rich).

2.3 Resource Family Trees based on Repurposing History and Inheritance

The term 'repurposing' refers to changing a learning resource initially created and used for a specific educational purpose in a specific educational context in order to fit a different new educational purpose in the same or different educational context. Although not formally addressed as such, educational content repurposing is what any educator is routinely engaged in when preparing a new educational experience, including preparing the educational content itself. Customarily, when an educator sets the context and goals of a new educational experience, he/she will overview existing content and/or search for new relative content and then repurpose and re-organize content to fit the purpose of the new educational experience.

There can be a variety of situations where repurposing educational content is desired. These situations, referred to as "repurposing contexts", can be of a pedagogical nature, a technical nature or both, and include the following [12],[13]: re-purposing (1) in terms of the actual content; (2) to different languages; (3) to different cultures; (4) for different pedagogical approaches; (5) for different educational levels; (6) for different disciplines or professions; (7) to different content types; (8) for different content delivery media and/or technology; (9) to educational content from an initial content type that is not intended for education; and (10) for people with special needs.

Considerable research work has targeted the field of automatic learning resource repurposing, e.g. [14],[15],[16],[17]. Only few works have really concentrated on modelling repurposing history of the content. The problem of the granularity level at which the modifications should be described is posed in [18], where the approach is to track content changes only in structural, layout and content aspects of the content (i.e. insert, delete, replace, rearrange). A shift from tracking structural changes towards studying changes in the educational context is seen in the repurposing of a specific content type (that of virtual patients) as addressed in the eVip/ReVip projects [13]. Finally, the MURLLO project from the community of language teachers, considers repurposing by tracking the changes in the "contextual metadata" that describe the intended teaching context [19]. Interestingly, metadata modifications that account for repurposing are carried out collaboratively based on Wiki technology.

In our work, we address repurposing as a means to provide a different kind of sociality for the educational resources. Thus repurposing history and inheritance are used as basic social relationship among educational resources in order to cluster resources into families. Each repurposed resource declares its parent(s) resource(s). Following iteratively the 'parents' in a chain of repurposing ancestors, the entire 'family' tree of the particular resource can be compiled.

2.4 Semantic Links between Resources by Harvesting the Linked Data Cloud

Finally, the social dimension of educational resources can be further expanded and enriched by harvesting semantically rich information existing in the Linked Data cloud. The Linked Open Data (LOD) approach is simply about "using the Web to create typed links between data from different sources. These may be as diverse as databases maintained by two organisations in different geographical locations, or simply heterogeneous systems within one organisation that, historically, have not easily interoperated at the data level [20]. The Linking Open Data Project [21] is a community project of the World Wide Web Consortium's Semantic Web Education and Outreach Group (W3C SWEO). The goal of the project is to extend the Web with a data commons by publishing various open data sets on the Web, and making links between data items from different data sources. Since its inception in June 2007, the size of the cloud has rapidly exploded and already includes a large variety of open data sets including several research and medical data sets. This wealth of information can be used to automatically enrich educational resources metadata with references to external vocabularies, and in particular domain specific vocabularies, thus creating a rich domain specific profile and extending the resource's social connections to other web objects. For example, in medical education the BioPortal [22] enables searching, sharing, visualizing, and analyzing a large set of biomedical ontologies, terminologies, and annotations exposed as LOD.

3 A Semantic Social Network for Educational Content Sharing

The various ways of exploiting educational resources as social objects have been implemented in the MetaMorphosis+ social network [1], which can be viewed as two distinctive and interacting networks. The first one is a network of persons, including authors, potential authors and final users of learning objects (students, or teachers or others, e.g. educational managers, etc). The second is a network of published learning resources. The network of persons is functioning in a way similar to other social networks. Persons can interact with each other via their personal blogs, declare friends and create their own interest groups. At a different level, learning resources themselves create an equivalent social network with interactions with other learning resources as well as with persons. These interactions are variable and dynamic, thus create an evolving, user centric and goal oriented organization of resources and persons, based on social dynamics.

From the point of view of the resources' social network, interactions are more complex. Each resource is described by a variety of fields that capture its basic characteristics as well as features pertaining to repurposing. This collection of fields forms the resource profile and is a virtual representation of the resource in the social network of resources. Educational resources are distributed, and they can reside anywhere on the Web (e.g. within a Learning Management System, another on-line repository, a Web page, etc), as long as their URL is known. MetaMorphosis+ only holds their metadata description and the pointer to their actual location.

The organization of educational resources is dynamically created around the four different social aspects presented in the previous section, as shown in Fig. 1. A most straightforward organization is created on the basis of user generated tags that constitute the resource profile as a set of metadata.

A second type of organization is a hierarchical one, describing the repurposing history of each resource. Each repurposed resource declares its parent(s) resource(s) and thus a dynamic organization of the resources in 'families' is generated. In MetaMorphosis+, a force-directed graph is used to depict the specific resource's family and inheritance patterns. Each node in the graph represents a resource, while the directed edges represent repurposing relationship, with the arrows pointing from the "source" objects to their "repurposed" descendants. The nodes also state the 'repurposing context', while they are active links to the resource profile where more information on the repurposing description can be obtained. For the entire resource collection, a circular directed graph representation is used which depicts all the resources with the various individual inheritance trees, usually not interconnected amongst them. A resource inheritance tree is a group of resources that have a relationship based on repurposing – this can also be viewed as resource 'family'.

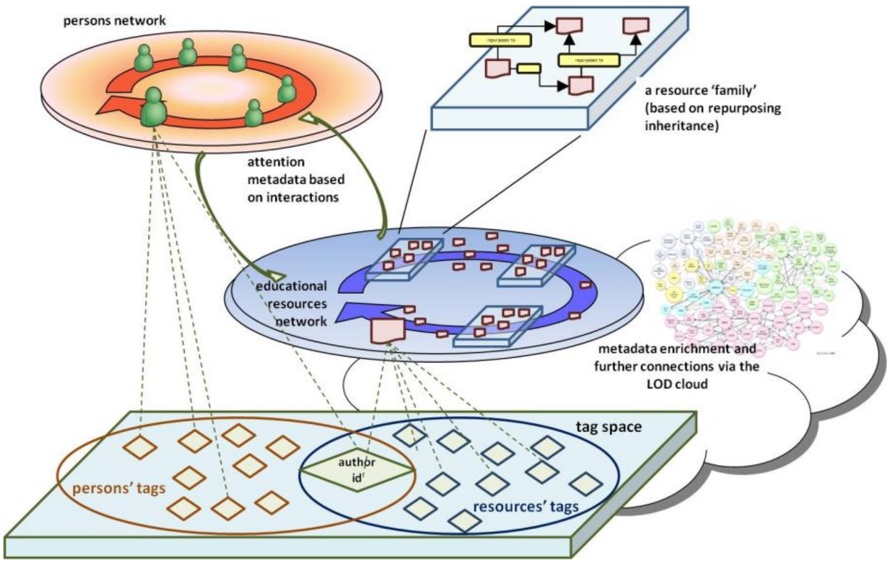

Fig. 1. A schematic representation of the double network organization in MetaMorphosis+ showing the different social aspects of the educational resources.

The third dimension in the social organization of resources is based on a model for framing the representation and treatment of information gathered from the reuse and repurposing of learning resources from distributed repositories [23]. The model takes into account as sources of information both static user-edited or automatically generated metadata fields and the emerging, dynamic information clouds that surround a learning resource when users comment on it, tag it, or explicitly link it to other learning resources, i.e. by a combined use of strict taxonomies/controlled vocabularies with folksonomies (dynamic, user's tags facilitators/aggregators). By coordinating these separate information layers, we hope to reduce the semantic gap occurring when unanticipated contexts of use are to be described by resorting only to predefined vocabularies, and thus to improve the relevance of the retrieved resources after a query.

Finally, the social profile of the educational resources is augmented by semantic tagging. The architectural framework for semantic data and service linking and federating of disparate educational resource pools that powers the social environment is described in detail elsewhere [24]. At the lower level of this semantic technology framework, a Web data and service layer employs distributed Web services that harvest educational resource metadata from heterogeneous data sources on the Web. In the upper layer, semantic data and service integration is achieved based on the Linked Services approach and on semantic technologies such as iServe [25] and SmartLink [26]. An RDF repository exposes harvested educational resource metadata as triples.

Metadata as harvested by Web sources can also be enriched with existing LOD vocabularies). This is of particular importance to extend rather unstructured metadata, such as keywords or free text subject and discipline descriptions with structured data based on well-known vocabularies. This is achieved by exploiting a variety of medical domain ontologies and the expanding LOD cloud to semantically annotate the existing RDF description of a resource and then expose its metadata back to the LOD cloud for further exploitation by third parties which make use of the web of LOD.

Biomedical ontologies provide essential domain knowledge to drive data integration, information retrieval, data annotation, natural-language processing and decision support. BioPortal (http:// bioportal.bioontology.org) is an open repository of biomedical ontologies that provides access via Web services and Web browsers to ontologies developed in various formats including OWL, RDF, OBO format and Protégé frames [22]. In MetaMorphosis+ we have utilized the NCBO BioPortal's RESTful Web services programming interface to access and incorporated terms and concepts from the more than 260 ontologies provided to this day, corresponding to more than 4.5 million medical and life sciences terms. This way the MetaMorphosis+ user can annotate an educational resource with suggested standardized terms and concepts from a variety of ontologies, enriching the RDF output with dereferencable standardized terms as values for the various fields, e.g. keywords, discipline, specialty, etc. The ontologies used include amongst else for prominent medical ontologies such as SNOMED-CT (Systematized Nomenclature of Medicine – Clinical Terms), ICD9/10 (International Statistical Classification Diseases and Related Health Problems), Body System (body system terms used in ICD11), MeSH (Medical Subject Headings), NCI (Meta)Thesaurus, Galen (the high level ontology for the medical domain), HL7 (the Normative RIM model v2), Biomedical Resource Ontology (BRO, a controlled terminology of resources to improve sensitivity and specificity of Web searches).

As an example, suppose a user intends to describe an educational resource by using the term/concept Telemedicine, in the list of 'Keywords' or in the 'Discipline' and 'Specialty' fields of the metadata description of the educational resource. Semantic annotation in MetaMorphosis+ can suggest a number of related standardized terms from the available ontologies. For example, the equivalent term from the NCI Thesaurus is represented by a dereferencable URI, (namely http://ncicb.nci.nih.gov/xml/owl/EVS/Thesaurus.owl#Telemedicine), thus enabling rich linking and reasoning within the semantic Web. Figure 1 shows an example of RDF triples in the mEducator scheme before and after semantic annotation in MetaMophosis+.

The current deployment of MetaMorphosis+ social network is implemented using the Elgg open source social engine (http://elgg.com) and is available on-line on http://metamorphosis.med.duth.gr. Additionally, FOAF (Friend-of-a-Friend) ontology is used for integration of human profiles, while Triplify [27] is employed to publish metadata profile fields as Linked Data. Graph representation was implemented based on the Prefuse information visualization toolkit (http://www.prefuse.org) and is based on the GraphML (http://graphml.graphdrawing.org/) standard and a FOAF/GraphML standard interface so as to dynamically extract the data and form the graphical representation at the time of request.

before enrichment

```
- <mdc:subject>
  - <mdc:Subject rdf:about="http://meducator.open.ac.uk/metamorphosis#subject1247265680">
      <rdfs:label>Thrombolysis </rdfs:label>
    </mdc:Subject>
  </mdc:subject>
  <mdc:description>ECG case 1004 limb and chest leads</mdc:description>
  <mdc:technicalDescription>PDF</mdc:technicalDescription>
  <mdc:resourceType rdf:resource="http://purl.org/meducator/mediaType#sketchGraphicalAnnotation"/>
  <mdc:resourceType rdf:resource="http://purl.org/meducator/mediaType#image"/>
- <mdc:discipline>
  - <mdc:Discipline rdf:about="http://meducator.open.ac.uk/metamorphosis#discipline1351316776">
      <rdfs:label>cardiology </rdfs:label>
    </mdc:Discipline>
  </mdc:discipline>
```

after semantic enrichment

```
- <mdc:subject>
  - <mdc:Subject rdf:about="http://meducator.open.ac.uk/ontology/SNOMEDCT/51308006">
    - <rdfs:seeAlso>
        http://purl.bioontology.org/ontology/SNOMEDCT/51308001
      </rdfs:seeAlso>
      <rdfs:label>Thrombolysis</rdfs:label>
      <mdc:externalSource>SNOMED Clinical Terms </mdc:externalSource>
    </mdc:Subject>
  </mdc:subject>
  <mdc:description>ECG case 1004 limb and chest leads</mdc:description>
  <mdc:technicalDescription>PDF</mdc:technicalDescription>
  <mdc:resourceType rdf:resource="http://purl.org/meducator/resourceType/Sketch-graphicalannotation"/>
  <mdc:resourceType rdf:resource="http://purl.org/meducator/resourceType/IMAGE"/>
- <mdc:discipline>
  - <mdc:Discipline rdf:about="http://meducator.open.ac.uk/ontology/SNOMEDCT/51308001">
    - <rdfs:seeAlso>
        http://purl.bioontology.org/ontology/SNOMEDCT/51308001
      </rdfs:seeAlso>
      <rdfs:label>Cardiology</rdfs:label>
      <mdc:externalSource>SNOMED Clinical Terms </mdc:externalSource>
    </mdc:Discipline>
```

Fig. 2. The above depictions of RDF/XML snippets show the differences of the RDF output before (above) and after (below) the semantic enrichment via the BioPortal. Before enrichment the values for the ‘Keyword’ and the ‘Discipline’ fields appear as strings with no linking to an ontology, while after enrichment these values are substituted with dereferencable URIs corresponding to standardized ontology terms.

The main goal of this implementation is to collect and organize pilot educational content within the mEducator project and test and re-engineer the metadata scheme for describing educational content in medical education. During the first few months of deployment the environment exhibits more than 100 registered users and more than 350 educational resources, including 80 repurposed resources. Although about half of the resources are in English language, there is a representation of more than 15 other European languages. The resources included in the environment are distributed among the various educational levels, 33% intended for undergraduate medical education, 23% intended for postgraduate/resident studies and 21% for continuing life-long education, while 22% are intended for educating the public. The majority of resources are of conventional content types, such as lecture notes and books (34%), lecture presentations (12%) and graphs/diagrams/figures/images (16%). Clinical cases, teaching files and virtual patients are 12% of available resources, while there is a small but notable representation of Web 2.0 type resources (4%), serious games (2%), algorithms (4%), and simulators (1%). When it comes to the repurposed resources, 84% of them have only one parent, while the rest declare two parent resources. A total of 42% of the repurposed resources have declared 2 repurposing contexts and 22% more than two repurposing contexts. All repurposing contexts are well represented, with repurposing to "different technology", and "different educational level", being the most common.

4 Discussion

In retrospect, it is possible to identify three generations of information technology supported learning. The first generation is based on multimedia technology support, such as videos, CD-ROMs or other stand-alone educational software. The second generation employs telematic technologies and it is basically set up as teaching via the Web, where conventional educational material, and entire educational courses, is delivered via the network to remote students. The last, emerging generation, is about Web based learning, where the Internet is used as a means to create active, context based, personalized learning experiences. This last generation of e-learning shifts the emphasis from 'teaching' to 'learning' and from the notion of technology as a didactic mediator to the notion of a sociable, peer-supported, involved learner. This new learning paradigm inevitably places emphasis on educational resources and virtual communities of practice. Although a lot of effort has been put in the area of educational content development, description, and sharing, currently there is no prominent clear and standards-based solution for the seamless sharing of educational content in medicine and in general.

Current efforts mainly address the problem of educational content sharing via centralized or distributed repositories, but such approaches do not consider notions such as author/learner participation and collaboration, nor do they address issues of usage and inheritance as resources are shared, re-used and repurposed. The MetaMorphosis+ social network presented in this paper presents a novel approach for capturing the multi-faceted social aspect of educational resources, as they form the social-object basis of a human network of educators and learners. The goal is to provide a conceptually different approach to educational resource search and retrieval via 'social' associations amongst learning resources and their authors and ultimate consumers.

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