Depicting Educational Content Repurposing Context and Inheritance

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***Abstract*—Educational content is often shared among different educators and is enriched, adapted, and, in general, repurposed so that it can be reused in different contexts. This paper discusses educational content and content repurposing in medical education, presenting different repurposing contexts. Finally, it proposes a novel approach to content repurposing via Web 2.0 social networking of learning resources. The proposed social network is augmented by a graphical representation module in order to capture and depict the relationships among different repurposed medical educational resources, based on educational resource "families" and inheritance. The ultimate goal is to provide a conceptually different approach to educational resource organization and retrieval via "social" associations among learning resources.**

***Index Terms*—Content repurposing, educational resource, medical education, social networking.**

I. Introduction

CONTINUOUS advances in medicine and biological sciences lead to an ever-expanding core knowledge relevant to the medical practice. Thus, medical academic institutions are increasingly required to invest in order to enrich their curricula by developing overspecialized courses and corresponding educational content. Educational content in medicine is produced by academics and clinical teachers based on accepted scientific knowledge, as well as by clinicians and researchers on the field, be it the hospital, the medical ward or the clinical, and/or research laboratory. Therefore, educational content in medicine includes a broad range of learning resource types and is customarily produced by a variety of sources. Another important factor that adds to the complexity, variability, and uniqueness of medical educational content is the growing penetration of active learning approaches in medical education [1]. Contemporary medical education, on a good degree, is based on case-based or problem-based learning and other small group instructional models, collaborative organizations to support student–faculty interactions, and technology-enhanced educational tools. Here, we should also stress the fact that medical knowledge is simultaneously explicit and implicit with certain aspects already well known and easily transferable, and others that are not yet fully known but must still be learned (e.g., by observation of task performance, and recursive practice)—what is usually referred to as tacit or personal knowledge [2], [3].

In retrospect, it is possible to identify three generations of information technology supported learning in medicine [4]. 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, are 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. Thus, during the last decade, a considerable number of regional and institutional digital repositories of educational material in medicine have been launched, e.g., [5]–[8]. However, considering the state-of-the-art nature of medical educational content, the breakthrough lies in the potential for sharing, reuse, modification, and repurposing of such content among medical educators and learners on a world-wide scale [9]. 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, reused, and repurposed.

This paper discusses different perspectives of content repurposing in medical education and presents a novel approach for sharing educational resources, via the MetaMorphosis social network developed partly within the mEducator project. mEducator is an EU funded best practice network (under the

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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 reused across European higher academic institutions. The emphasis of the work presented here is on capturing the repurposing context, and the repurposing history and inheritance of educational resources as they are shared, used, and repurposed within a participatory virtual community of authors and learners [10].

II. Educational Content Repurposing

The majority of activities in the field of e-learning to date have focused on reuse of complete educational content items with a fixed combination of structure and content. While the value of this approach is not disputed, critical issues of deep, conceptual understanding, a sense of ownership and wider issues of cultural assimilation remain unresolved. These issues alone can determine the success or failure of educational innovations, regardless of technical robustness, accessibility, and quality of content. Thus, it has been argued in the literature that fully supported opportunities for teachers to "repurpose" object structures through a participative design process is the path most likely to lead to the elusive goal of reuse of digital learning objects by a critical mass of teachers [11]. 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 reorganize content to fit the purpose of the new educational experience. Therefore, the term repurposing needs to be distinguished from the term reuse, which refers to the reuse of an educational resource "as is" [12]. 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 [13], [14]: repurposing 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. For example, the common case of creating a new PowerPoint® presentation out of a repository of related presentations [15]. In this study, the content of the PowerPoint® presentation (slides, notes pages, etc.) is extracted and stored as text. Text is then parsed and augmented with tags, which are used to annotate each word with its syntactical form. This approach allows the dynamic extraction of similar presentations, query by example and document-level similarity checking (at document, at topic, and at a slide level). A central issue in related studies is the model used (if any) to describe the content, the level of aggregation and packaging of an educational item. Indeed, the structure and composite nature of a learning content item is still open to interpretation [16]–[18]. Some research on ontologies has been conducted to address this issue. The ALOCoM [19] ontology is such a representative example of an attempt to provide an explicit vocabulary and a conceptualization of the structure and aggregation level of learning content. Similarly, the TRIAL-SOLUTION project defines an ontology for learning objects that includes mathematical categories (e.g., definition, theorem, proof, example), with the goal to create and deliver personalized teaching materials that are composed from a library of existing documents on mathematics at an undergraduate level [20]. The perspective of domain specific ontology for learning object management is commonly adopted. A prominent example is the ARIADNE project, which has put a lot of effort to enable educational content sharing and reuse, however, resulted in a complex and hard to use system, as it basically reflects the metadata standard rather than the characteristics, aims, and requirements of the end user [21]. Research work also includes efforts to develop the means for content repurposing to accommodate people with special needs. An example is the Digital Talking Books (DTB) framework, which supports the production of automatic generation of multimodal digital talking books from original raw materials (tapes and text), and provision of fundamental mechanisms to identify, extract, and store excerpts of digital spoken books, to enrich them with other media and to combine them into new perspectives, stories, or documents [22].

Apart from automatically repurposing learning resources, research into repurposing may address requirements such as keeping track of a learning object evolution, in order to 1) give credentials to original authors and sources and provide information that may have implications for the object's quality, validity, specificity, etc; 2) record and resolve intellectual property rights issues of content as it is being repurposed and reused; and 3) update a learning resource, or a fragment of it, when its parent resource is updated, changed, terminated, etc. Only few works have really concentrated on modeling repurposing history of the content. The problem of the granularity level at which the modifications should be described is posed in [23], 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 toward 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 [14].

Recently, research is starting to draw from Web 2.0 notions and technologies to provide a different approach to content repurposing issues. For example, social tagging has been proposed as an alternative approach to content organization, search, and retrieval in educational content repositories [24]. Another similar approach is exploited in the MURLLO project, where Web

2.0 technologies are employed to create an integrated framework for effective repurposing of reusable learning objects. In this approach, a wiki is proposed for the seamless authoring and repurposing of learning objects (thus allowing storage of content and all its versions), while additional services allow metadata creation to describe educational content and support searching [25].

In this study, Web 2.0 notions are also employed to give a different perspective to educational content repurposing, by creating social networks of educational resources where, among else, repurposing history and inheritance are used as basic social relationships among educational resources in order to drive object organization, retrieval, evaluation, and reuse.

III. Metamorphosis Social Network

A. Double Network of Humans and Resources

The proposed MetaMorphosis social network can be viewed as two distinctive and interacting networks [13]. 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 online 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 in three different distinctive levels, as shown in Fig. 1. A most straightforward organization is created on the basis of authorship, i.e., resources that share the same author, as denoted by the common author id tag, see Fig 1(a). A second complex and dynamic organization is created based on the user generated tags that have been declared to describe educational resources (as part of their resource profile, discussed in more detail below), in a similar fashion as in any conventional social network, thus creating a variety of "social" groups—the resources' network, see Fig 1(b). Finally, a third type of organization is a hierarchical one, describing the repurposing history of each resource, see Fig. 1(c). 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. Currently, the environment supports basic search functionality based on the words and text in the metadata fields that form the profile of a resource. Additionally, there is the dynamic organization of the resources in "families" based on their repurposing inheritance and alternative dynamic organizations into social groups and collections, following conventional organization in social networks based on common profile tags.

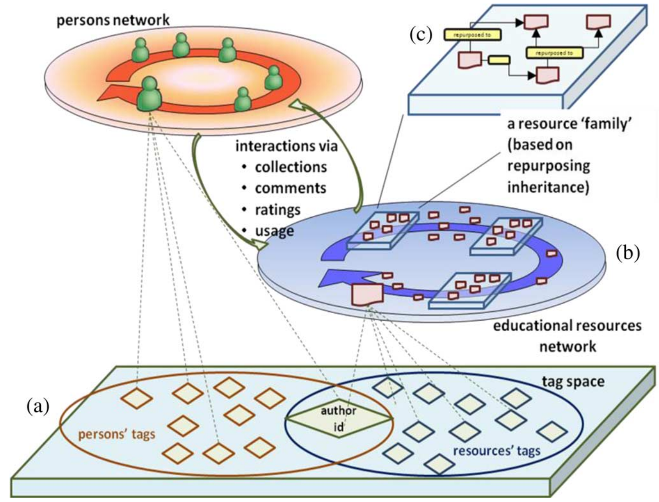

Fig. 1. Three level dynamic organization and interaction of users and resources in the MetaMorphosis social network. As an example, the dotted lines represent connections of a human user and a resource via the tag space. An example of a resource "family" (based on repurposing inheritance) is shown in more detail.

B. Resource Metadata Description

An important issue of the MetaMorphosis social network is the profile for describing educational resources. Standardizing metadata for describing digital educational resources constitutes one of the main research topics in the e-learning community. In general, e-learning standards can be organized into various general categories [26] including metadata standards that specify the metadata used to describe the resource's attributes, such as the authors, title, and languages; such descriptions can be published along with the resource to facilitate their search and retrieval. Currently, the IEEE LOM (Learning Object Metadata) XML scheme seems the most prominent standard for describing learning objects (http://ltsc.ieee.org/wg12/20020612-Final-LOM-Draft.html) 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 as CLEO, and Educational Markup Languages) these only capture some of the semantics; thus more complex models are needed [27].

Using a standard such as LOM is not always easy, as: 1) filling in all the data requires effort; 2) not all data are relevant and useful to a particular author and/or prospective user; 3) many different metadata sets exist, with a considerable overlap; 4) some attributes are subjective, but a number of them are objective, e.g., difficulty. Some other attributes have predefined values, which themselves are objective, and there is a great difficulty in achieving a universal consensus about what they should mean. Thus, different communities give different meanings and use different descriptions (e.g., extensions/alterations to the standard, such as Healthcare LOM, etc.), really breaking down the notion of the standard. Whereas the earlier difficulties relate to issues of relevance, semantics, and usability, a more severe critique of learning object metadata standards [28] points out that the overarching epistemological assumption implied in the current ways of describing an educational resource is that "information equates learning." Although this may correlate nicely to industry oriented instructivist approaches, it certainly does not fit with in current constructivist learning theories that place emphasis on learning as a personal experience sustained by activity in a social context. Since metadata currently only describes simplified technical and structural characteristics of learning objects, a move toward 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 is advocated [28].

This approach is taken by the mEducator consortium in their 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 resource profile in MetaMorphosis follows the mEducator metadata scheme for educational content description, which is described in the generic standard Resource Description Framework and can be found in http://www.meducator.net/mdc/schema.rdf. Additionally, the Friend-of-a-Friend (FOAF) ontology is used for integration of human profiles, while Triplify [29] is employed to publish metadata profile fields as Linked Data [30]. The term Linked Data refers to a set of best practices for publishing and connecting structured data on the Web. These best practices have been adopted by an increasing number of data providers over the last three years, leading to the creation of a global data space containing billions of assertions—the Web of Data, which is the emerging realization of the semantic web. Implementing the earlier standards, educational resources and humans participating in the MetaMorphosis environment are directly made a part of the semantic web. The mEducator metadata scheme includes a number of fields addressing different aspects of the educational resource: 1) general fields: resource title, unique identifier, URL, URN, intellectual property rights clearance/license, quality stamp (if any); 2) 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); 3) 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; 4) fields related to classification/taxonomy information: resource language, type, discipline, discipline subspecialty, educational level; and 5) fields addressing repurposing: resource parents, repurposing context, repurposing description. "Resource parents" is used to capture the repurposing history and via this relationship a directed graph-like inheritance tree of repurposed resources can be constructed. "Repurposing context" exhibits the predefined contexts as described in Section II, while "repurposing description" is a free-text entry to allow for a more detailed description of the repurposing process.

C. *Depicting Repurposing Inheritance*

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 among 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."

An example is shown in Fig. 2. In this example, the initial resource is titled "Climate Health Impact Game," and is in fact a serious game intended to introduce health impact of global warming to biology students. This resource has been repurposed into three different resources, as shown by the three directed graph edges stemming from the resource's node. Two of the new resources are instances of the initial resource repurposed to a different language, while the third is a quiz and has been created via repurposing the initial resource to a different content type (i.e., a quiz instead of the initial serious game) and different pedagogy (i.e., of learning via self-assessment instead of exploratory game via a serious game). Furthermore, there is one more "generation" in the particular resource "family," as this third repurposed resource exhibits a descendant of its own, i.e., a new resource that has been created via repurposing the Climate Health Impact quiz to a different language.

D. *Implementation and Deployment*

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. Elgg runs on a combination of the Apache Web server, MySQL database system, and the PHP interpreted scripting language. 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 on FOAF/GraphML Standard interface so as to dynamically extract the data and form the graphical representation at the time of request. The main goal of this implementation is to collect and organize pilot

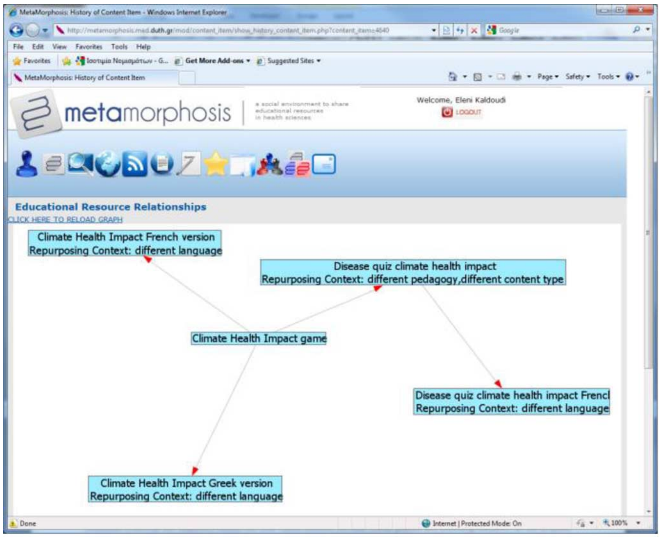

Fig. 2. Graphical representation a specific "family" of resources, i.e., resources that are connected via a repurposing relationship.

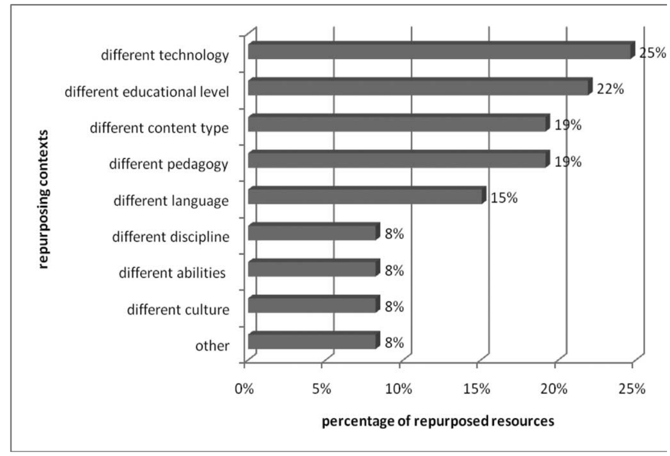

Fig. 3. Declared repurposing contexts as a percentage of repurposed resources (for a total of 73 repurposed resources out of 316 resources).

educational content within the mEducator project and test and re-engineer the metadata scheme for describing educational content. During the first few months of deployment the environment exhibits more than 70 registered users and more than 300 educational resources, including 73 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 two repurposing contexts and 22% more than two repurposing contexts. This may indicate that repurposing is a rather complex procedure with a number of different goals at the same time. In any case, the frequency of various declared repurposing contexts is shown in Fig. 3. It is evident that all repurposing contexts are well represented, with repurposing to "different technology," and "different educational level," being the most common.

Two focus groups of academic teachers in medicine were formed and the participants were presented with two (2) use case scenarios, designed to assess the activities of describing a resource along the provided profile fields, of resource repurposing, of sharing resources, and searching for resources. The scenarios addressed mainly qualitative characteristics and were pivoted around the notions of "creating metadata" or "searching for resources." In the first, the focus group discussions enlightened the issues associated with the description of resources, the description of repurposed resources, the usage of controlled vocabularies, and generally the sharing of resources, while in the second emphasis was placed around the issue of "search best practices." Other qualitative indicators included investigations around questions like "Who is creating the metadata?," or "Who is validating the metadata?," or "How much time is required to fill-in metadata fields?," as well as "How familiar are users with the Web?" Methodology-wise, a facilitator was going through the two aforementioned scenarios and the participant interactions were recorded; the facilitator summed up the main conclusion points at the end of each scenario interaction, as well as, at the end. Participants were positive on sharing their content with others (mainly for personal reputation, visibility, and academic recognition); however, they noted time constraints that might put educational content sharing lower in their priority list. Although professional university teachers, participants found it rather difficult to comprehend fields related to educational description of the resource and indicated that predefined taxonomies and controlled vocabularies would be helpful, although time consuming. Participants indicated that repurposing description could be more comprehensible if amended with additional fields indicating the reason for repurposing and listing major differences between the repurposed and original resources. The study also highlighted a common misconception among participants, who failed to comprehend that the search mechanism is limited only to metadata. It was indicated that a mechanism for searching based on semantics and relevancy, rather than on metadata fields alone, would be desirable.

IV. Discussion

Recent technological advances have induced a concept and paradigm shift for the local, opinion-driven physician approach toward the global expert notion, including aspects of evidence-based medicine and information aggregation toward individualized patient care. This modifies quickly and essentially not only the way health care professionals work, but also the way medical educational processes are designed and hopefully practiced, placing requirements for adaptive and ubiquitous online expert educational content sharing. Technology-supported educational interventions are usually successful when specific training requirements are aligned with the learning potential and the educational use of technology. Thus, requirements for flexible, adaptive, and ubiquitous online content sharing should evoke notions, practices, and technologies from respective state-of-the-art evolutions of the Web technologies, namely, the emerging paradigm of participative, collaborative Web 2.0.

The MetaMorphosis social network presented in this paper presents a novel approach for capturing the repurposing of medical learning resources. Repurposing of learning resources is described using metadata, which can be edited collaboratively in a social network, either by the instructor, or the student (and eventually even by software itself). The social network is also used to capture and depict the relationships among different repurposed medical learning resources. The goal is to provide a conceptually different approach to educational resource search and retrieval via "social" associations among learning resources and their authors and ultimate consumers.

An important issue in educational content sharing and repurposing is intellectual property rights and respective licenses. Current trends in research and education promote alignment with the context of Budapest Open Access Initiative (http://www.soros.org/openaccess/read.shtml). "Open access" means the free availability of works on the public Internet, permitting any users to read, download, copy, distribute, print, search, or link to the full texts of these articles, crawl them for indexing, pass them as data to software, or use them for any other lawful purpose, without financial, legal, or technical barriers. The only constraint on reproduction and distribution, and the only role for copyright in this domain, should be to give authors control over the integrity of their work and the right to be properly acknowledged and cited. While "open" means "without cost," it does not follow that it also means "without conditions." This conditional use of educational resources could be best served by The Creative Commons licenses (http://creativecommons.org), probably the most notable and most often used tools in the arsenal of legal means with the aim to contribute to "open access" information commons. Although MetaMorphosis does not deal directly with educational content (it rather describes, links, and redirects to content), it does provide the advanced functionality of IPR resolution of content, if and when this is desired by the author, by redirecting to the Creative Commons service. It is notable that currently 64% of resources in MetaMorphosis exhibit a Creative Commons license, while only a 19% have no license scheme declared.

As an added value to the functionality of MetaMorphosis social network, we are currently working on a model for framing the representation and treatment of information gathered from the reuse and repurposing of learning resources from distributed repositories [31]. 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) [32]. 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.

Another approach to enhance searching is to exploit semantic tagging of resource profiles. Currently, metadata is published as semantically tagged Linked Data, and as such it can be harvested by generic semantic search engines. However, there is no dedicated semantic linking of resources within MetaMorphosis among themselves and with related data on the Web. Thus, work in progress involves research and deployment of a semantic Web services architecture to map profile fields to existing Linked Open Data vocabularies and ontologies, enrich existing metadata via identification of key terms, expand search queries via semantically related terms and retrieve additional relevant data from external sources.

The proposed approach of learning resources social networking has been deployed in order to study content repurposing in medical education within the European Best Practice Network "mEducator: Multi-type Content Repurposing and Sharing in Medical Education," under the eContentplus2008 Program. The ultimate goal is to provide an alternative view of learning content organization, management, and sharing for use and reuse across health care institutions, via "social" associations among learning objects with emphasis on their repurposing history and associations.

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