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Learning Objects Need Badly Instructional Digital Libraries Support

Mihaela-Monica VLADOIU
Department of Informatics, Petroleum-Gas University of Ploiesti
Bd. Bucuresti 39, Ploiesti, Romania
e-mail: mvladoiu@yahoo.com

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Abstract. In this paper, we present a standard definition for learning objects, a controversy around it, and the resulted working definition, along with features to be held by learning objects, benefits of the object-oriented approach for learning, some pros and cons for using learning objects, and finally some quality standard guidelines for these objects. In addition, we introduce shortly a taxonomy of learning object types and the metadata standards that can be used for learning objects and the way they inter-relate. An overview of the content and capabilities of the instructional digital libraries available on the web is presented too. We conclude by pointing out some possible solutions for meaningful use of the learning objects that can be found on the web, either by construction of really useful community instructional digital libraries, or by using non-authoritative metadata to find these learning resources. Involving the conscious user in the process of making sense of the huge quantity of learning resources to be available on the web is, in our view, the only straightforward way to having fast access to the most appropriate (instructional) resource that is needed for a particular (educational) aim.

Key words: learning objects, instructional digital library, metadata standards, non-authoritative metadata, scholar communities, community instructional digital libraries.

1. Introduction

E-learning, learning objects, instructional use of learning objects, instructional digital libraries, metadata, learning communities and much more related terms are very present in the literature and on the websites that have to do with education and instruction nowadays. There are numerous efforts to understand, explain, organize, and methodize all the issues related to instruction in order to facilitate a smooth meaningful education for learners. In our view, only by storing the learning objects, along with all the other elements related to instruction, into open instructional digital library which can be integrated in more general digital libraries, can provide for the availability and re-use of the instructional components to all interested instructional agents (human, software). Only this way, these instructional elements can be accessible to anyone, anywhere, anytime, and with significant cost-savings. Consequently, the educational effort can be focused on using those properly, according to the desired educational goals.

In this paper, we present firstly a standard definition for learning objects, a controversy around it, and the resulted working definition, along with features to be held by learning objects, benefits of the object oriented approach for learning, some pros and cons for using learning objects, and finally some quality standard guidelines for these objects. In the Section 3, we present shortly a taxonomy of learning object types. Section 4 introduces metadata standards that can be used for learning objects and the way they inter-relate, Section 5 is a brief overview of the content and capabilities of the instructional Digital Libraries (DLs) available on the web, Section 6 presents one possible solution for construction of really useful community instructional digital libraries, Section 7 introduces another valuable experience for building such DLs by using non-authoritative metadata combined with collaborative filtering, and finally, the last section lists some conclusions.

2. What Are the Learning Objects?

According with IEEE-LTSC-Learning Object Metadata standard that has become a de facto standard for learning object metadata, a Learning Object (LO) can be defined as **any entity, digital or non-digital, that may be used for learning, education or training** (IEEE-LTSC-LOM, 2003). This rather broad definition has been actively criticized by an important author, the most important it seems, in LO issues: David Wiley from Utah State University. According to his opinion, learning objects are elements of a new type of computer-based instruction grounded in the object-oriented paradigm of computer science. Object-orientation highly values the creation of components (called “objects”) that can be **reused** in multiple contexts. This is the fundamental idea behind LOs: instructional designers can build small (relative to the size of an entire course) instructional components that can be reused a number of times in different learning contexts. Additionally, LOs are generally understood to be digital entities deliverable over the Internet, meaning that any number of people can access and use them simultaneously (as opposed to traditional instructional media, such as an overhead or video tape, which can only exist in one place at a time). Moreover, those who incorporate LOs can collaborate on and benefit immediately from new versions. These are significant differences between LOs and other previous instructional media.

Wiley argues also that LTSC definition is extremely broad, and upon examination fails to exclude any person, place, thing, or idea that has existed at anytime in the history of education. Accordingly, different groups outside the Learning Technology Standards Committee have created different terms that generally narrow the scope of the canonical definition down to something more specific. Other groups have refined the definition but continue to use the term “learning object”. Confusingly, these additional terms and differently defined “learning objects” are all LTSC “learning objects” in the strictest sense.

So, the author proposes, as a working definition for a LO: **any digital resource that can be reused to support learning** (Wiley, 2001b). This definition includes anything that can be delivered across the network on demand, be it large or small. Examples of “smaller reusable digital resources include digital images or photos, live data feeds (like stock tickers), live or prerecorded video or audio snippets, small bits of text, animations, and smaller web-delivered applications, like a Java calculator”. Examples of “larger reusable digital resources include entire web pages that combine text, images and other media or applications to deliver complete experiences, such as a complete instructional event”.

This definition of a learning object, “any digital resource that can be reused to support learning”, is proposed for two reasons. First, the definition is sufficiently narrow to define a reasonably homogeneous set of things: reusable digital resources. At the same time, the definition is broad enough to include the estimated 15 terabytes of information available on the publicly accessible Internet. Second, the proposed definition is based on the LTSC definition (and defines a proper subset of LOs as defined by the LTSC), making issues of compatibility of LO as defined by Wiley and LO as defined by the LTSC explicit. The proposed definition captures what the author feels to be the critical attributes of a LO, “reusable”, “digital”, “resource”, and “learning”, as does the LTSC definition.

In addition to the ones said above, learning objects have to be standalone, discoverable, able to be aggregated, interoperable, based on a clear instructional strategy, interactive, tagged with metadata. Moreover, they are expected to provide for learning which is *just enough*, *just in time* and *personalized (just for you)* is said on the website of the project *Reusable Learning Objects (RLO)– a project at Tropical North Queensland (TNQ), Technical and Further Education (TAFE) Institute, Australia* (RLOs, TNQ-TAFE, 2003). To the question *What are the learning objects and what are their main characteristics?*, the TNQ-TAFE team answers that learning objects are:

- *A new way of thinking about learning content* – traditionally, content comes in a several hour chunks called “a course”. Learning Objects are much smaller units of learning, ranging for example, from 2 to 15 minutes;
- *Small, independent chunks of knowledge or interactions* – stored in a database can be presented as units of instruction or information.
- *Based on a clear instructional strategy* – intended to cause learning through internal processing and/or action. In order to be defined as a Learning Object there must be some intrinsic instructional value related to a knowledge or information object;
- *Self-contained (standalone)* – each learning object can be taken independently. Like Lego, RLOs are small standalone, reusable components – video, demonstrations, tutorials, procedures, stories, assessments, simulations, case studies, HTML/text pages etc. that can be assembled to provide resources for education and training. Objects have a defined level of *granularity* which means they can stand alone as single items or be combined (aggregated) with other objects to form larger instructional units. At one extreme at the micro level, they can be media assets – images, paragraphs of text, questions, audio/video clips, animations etc. At the other extreme an RLO can be regarded as a fully self contained piece of instruction. These differing levels have attraction for different users – the micro level is attractive to developers, but has no meaning at all to learner. The macro level is attractive to publishers who have an easy catalogue of products. What is certain that the level cannot be so small as to lose meaning to any one at all or so large as

to become inflexible and hinder personalization or contextualization. Some metadata standards, such as SCORM (Sharable Object Content Reference Model) and SOCCI (Schools Online Content Curriculum Initiative) allow for metadata description at various levels of aggregation such as the resource, item and LO level. The IMS standard uses "the relative size of the resource" as their working definition of granularity – relative sizes ordered from high to low "curriculum, course, unit, topic, lesson, fragment". A large resource has low granularity, a small one high granularity (RLOs, TNQ-TAFE, 2003);

- *Tagged with metadata* – every learning object has descriptive information allowing it to be easily found by a search;
- *Discoverable* – Learning objects must be able to be found. LOs must be tagged with appropriate descriptive metadata in order to be identified for the purpose they are to be put. Whilst the technical description of objects is being addressed via the various metadata schemas that have been developed, there are increasing calls from educators for the metadata schemas to improve the pedagogic description of learning objects;
- *Interactive* – each learning object requires that students view, listen, respond or interact with the content in some way;
- *Reusable* – a single learning object may be used in multiple contexts for multiple purposes. The main idea of Reusable Learning Objects (RLOs) is to break educational content down into small standalone chunks that can be reused in various learning environments, in the spirit of object-oriented programming;
- *Able to be aggregated* – learning objects can be grouped into larger collections of content, including traditional course structures;
- *Interoperable*: learning objects must be interoperable that is: content from multiple sources must work with different learning systems. In order to do this they must be designed according to appropriate standards;
- *Meant to* let learners have learning that is:
  - *Just enough* – if learners need only part of a course, they can use only the LOs they need;
  - *Just in time* – LOs are searchable, thus learners can instantly find and take the content they need;
  - *Just for you* – learning objects allow for easy customization of courses for a whole organization or even for each individual;

In an environment in which the context is scalable and adaptive, the ideal RLO content is seen as:

- modular, free-standing, and transportable among applications and environments;
- non-sequential;
- able to satisfy a single learning objective (although this depends on the granularity of RLO);

- ◦ accessible to broad audiences (adaptable to audiences beyond the original target audience);
- ◦ coherent and unitary within a predetermined schema so that a limited number of meta-tags can capture the main idea or essence of the content;
- ◦ not embedded within formatting so that it can be re-purposed within a different visual schema without losing the essential value or meaning of the text, data or images.

The object-oriented approach for learning objects has some built-in benefits:

- **Flexibility:** material, which is designed to be used in multiple contexts, can be reused much more easily. It is much easier to contextualize as part of design and development than to uncouple an object from the context of its parent course and then re-contextualize;
- **Ease of updates, searches and content management:** metadata tags facilitate rapid updating, searching and management of content by filtering and selecting only the relevant content for a given instructional purpose;
- **Customization:** when customization is required, the learning object approach facilitates a “just in time” approach to customization. Modular learning objects maximize the potential of software that personalizes content by permitting the delivery and recombination of material at the levels of granularity desired;
- **Interoperability:** the object-oriented approach allows organizations to set specifications regarding the design, development and presentation of learning objects based on organizational needs, while retaining interoperability with other learning systems and contexts;
- **Facilitation of competency based learning:** competency based approaches to learning focus on the intersection of skills, knowledge, and attitudes within the rubric of core competency models rather than the course model. While this approach has gained a great deal of interest among employers and educators, the challenge in implementing competency based learning is the lack of appropriate content that is sufficiently modular to be truly adaptive. The tagging of granular learning objects allows for an adaptive competency based approach by matching object metadata with individual competency gaps;
- **Increased value of content (reusability):** From a business perspective, the value of content is increased every time it is reused. This is reflected not only in the costs saved by avoiding new design and development time, but also in the possibility of selling objects or providing them to partners in more than one context.

Moreover, well-designed reusable learning objects can do even more for all the actors involved in instructional and educational experiences:

For developers and organizations:

- Shorter development cycles
- Cheaper development of online resources
- Ease of updates
- Interoperability assessment

For learners and organizations:

- Flexibility
- Customization
- Personalization
- Miniaturization
- Aid "just-in-time" training

"What they can **also** do for us, however is land us in court!" is affirmed by the TNQ team too. The need to be cognizant of good copyright practice and licensing to avoid litigation is of course of paramount importance to the concept of Reusable Learning Objects. The need to address and cater for this issue is of growing interest to central agencies worldwide, such as AEShareNet, GEM and MERLOT.

Interoperability and Usability – A Scenario (not too far from home). On the TNQ-TAFE project website is presented also the following scenario which is very probable to be experienced often in educators' and instructional designers' daily activity:

Suppose we are finally about to publish 500 pages of course content, complete with online quizzes, pictures that move and all sorts of cool stuff. It has taken 18 months of getting together funding, designing the site, writing the content, developing the multimedia. ANTA announces that the Training Package is up for significant review. Not too bad you think – they're putting out a Toolbox to go with it – we'll adjust a few pages, insert a few things, delete a few things. Won't take long? WRONG!

- *the 500 pages have a hard coded navigational system of "back" and "forward" buttons – inserting and deleting material means lots of tedious editing;*
- *as the Toolbox is designed for CD-ROM, not web, some of the image formats need extensive editing and access to sophisticated software to allow conversion;*
- *video is an integral component to the Toolbox presentation. This is far too large to place on the web so alternatives have to be found, necessitating rewrites of crucial content;*
- *some buttons on your site take the learner to different places depending on quiz scores. This requires communication with your Learning Management System. The new Toolbox provides quizzes in Authorware, which does not interact with your Learning Management System, so extensive reprogramming is necessary;*
- *Worse still, the Toolbox uses its own delivery engine, and passes results back in its own format to its own databases. Forget using these at all.*

These are all issues of *interoperability* (content from multiple sources working well with different learning systems) and *reusability* (content developed in one context being transferable to another context). Moreover, every time a course or unit or an interactive training manual needs to be updated, far more of the material must be rewritten than is necessary or desirable. In addition, the process of developing high-quality content is prone to unnecessary duplication of effort, driving up the cost, often beyond what the market will bear. Issues of Interoperability are being addressed by the standards agencies. Issues of reusability must be addressed at the design stage of the process.

On the Wisconsin Online Resource Centre Interactive Learning Objects website we can find some quality standards guidelines for LOs (Quality Standards Guidelines, 2003). Thus the learning object:

- shows a clear purpose, i.e., is immediately relevant to the learner;
- reflects a specified learning preference (visual, auditory or kinesthetic);
- supports the competency at the appropriate level (Bloom);
- helps learners understand the concept being presented;
- is able to be applied to courses in different subject areas;
- is able to be applied to different programs of study;
- can be grouped into larger collections of content, including traditional course structures;
- requires interaction on the part of the learner with the learning materials, i.e., responding and acting to apply higher-order thinking skills;
- can stand alone, i.e., is not dependent on external sources (textbook chapters, videos);
- contains all information and materials needed by learners to complete the activity, e.g., introduction, conclusion, learning content;
- is easy to use for the learner;
- applies appropriate Principles of good practice;
- applies appropriate learning college principles.

The Pros and Cons for reusable learning objects can be summarized in Table 1 (RLOs, TNQ-TAFE, 2003).

Armed with a working definition of the term Learning Object and with an overview of their expected features, the discussion of the instructional use of learning objects and their availability within current claimed instructional digital libraries can proceed.

3. Taxonomy of LO Types

All LOs have certain qualities. It is the difference in the degree to which or manner in which they exhibit these qualities that makes one type of LO different from another. This section presents a taxonomy of LO types with which the designer should familiarize oneself. This section is included as reference, and does not contain any design prescriptions. This taxonomy identifies five types of LOs. Examples of these five object types are given below, followed by the taxonomy, which explicates their differences and similarities (Wiley, 2000c):

- *Single-type* – an individual digital resource uncombined with any other, the Single-type LO is generally a visual (or other) aid that serves an exhibit or example function (for example, a JPEG of a hand playing a chord on a piano keyboard);
- *Combined-intact* – a small number of digital resources combined at design time by the object's creator, whose constituent LOs are not individually accessible (recoverable) from the Combined-intact object itself. The Combined-intact LO may contain

Table 1

Pros and cons for learning objects

	PROS	CONS
Production Costs	By properly breaking content into RLOs, different parts can be maintained and updated separately. If a suitable learning object can be found, a new one does not need to be created. These are cost savers.	Changing to a learning object approach from a "self contained system" approach involves retooling and retraining costs.
Flexibility	As more and more standards based learning objects become available, increased choice will translate into more flexibility for designers.	Using standards based LOs restricts the scope of learner information that is accessible by content if total interoperability is maintained.
Pedagogy	Learning objects fit nicely into many instructional design theories. Instructional templates can be created with slots for specific types of learning objects. LOs may encourage designers to operate in more disciplined ways with positive effects.	Restrictions on learner information could restrict pedagogical approaches. Approaches using lengthy discursive material may not benefit from the use of LOs.
End User Cost	The learning object approach prevents consumers from being locked into specific systems. As standards take hold, the market for content will take on more of the properties of a typical consumer market with lower costs and increased choice.	The cost of converting existing content to a LO approach may be significant.
Industry Support	All leading system vendors and content producers are supporting SCORM and other standards that are based on or that complement a learning object approach.	Realistically, it is twelve to eighteen months between the time the vendor community adopts an approach and the time products that implement the approach are available.

limited logic (e.g., the ability to perform answer sheet referenced item scoring) but should not contain complex internal logic (e.g., the capacity to independently grade a set of item forms or case types). Combined-intact LOs should be single purpose, that is, they should provide either instruction or practice (for example, a video of a hand playing an arpeggiated chord on a piano keyboard with accompanying audio);

- *Combined-modifiable* – a larger number of digital resources combined by a computer in real-time when a request for the object is made, whose constituent LOs are directly accessible (recoverable) from the Combined-modifiable object. Combined-modifiable LOs frequently combine related instructional and practice-providing Combined-intact and Single-type objects in order to create a complete instructional sequence (for instance, a web page dynamically combining the previously mentioned JPEG and QuickTime file together with textual material, on-the-fly);
- *Generative-presentation* consists of logic and structure for combining or generating and combining lower-level LOs (Single-type and Combined-intact types).

Generative-presentation LOs can either draw on network-accessible objects and combine them appropriately or generate (e.g., draw) objects and combine them to create presentations for use in instruction, practice, and testing. (Generative presentation LOs must be able to pass messages to other objects with assessment logic when used in practice or testing). While Generative-presentation LOs have high intra-contextual reusability (they can be used over and over again in similar contexts), they have relatively low inter-contextual reusability (use in domains other than that for which they were designed). For example, a JAVA applet capable of graphically generating a set of staff, clef, and notes and then positioning them appropriately to present a chord identification problem;

- *Generative-instructional* consists of logic and structure for combining LOs (Single-type and Combined-intact types) and evaluating student interactions with those combinations, created to support the instantiation of abstract instructional strategies (such as “remember and perform a series of steps”). The Generative-instructional LO is high in both intra-contextual and inter-contextual reusability (for example, an EXECUTE instructional transaction shell, which both instructs and provides practice for procedures, for example, the process of chord root, quality, and inversion identification).

Distinguishing between the LO types is a matter of identifying the manner in which the object to be classified exhibits certain characteristics. These characteristics are critical attributes and are stable across environmentally disparate instances (e.g., the properties remain the same whether or not a digital library of LOs exists or not).

4. Metadata Standards for Learning Objects

Metadata is simply “data about data”. It provides information about an electronic document or item in much the same way as a library catalogue card provides information about a book. The metadata can sit within the item, such as in the head section of a HTML document. It cannot be seen on the HTML page, but can be seen in the underlying HTML code (a click on “view source” in a browser will allow the viewing of the Dublin Core metadata for that page). It can also be stored separate from the item in a database either linked to the resource (a repository), or giving a location where the resource can be found (a catalogue or directory).

Metadata consists of a set of elements or fields that describe the resource, such as author, date, title etc. In the case of a learning object such as a web video or animation, this metadata also needs to hold information about the file format, size, and software required etc. Some metadata elements can be broken down into standard sub-elements called “qualifiers”. Some metadata elements or fields can only be described in a certain way, so that the terminology used to describe resources is the same worldwide by both developers and searchers. This is known as a “controlled vocabulary”.

To be effective, metadata needs to conform to standards so that interoperability between different computer applications can be achieved and so that searchers can use a standard set of retrieval techniques to maximize their chances of finding the resources via a search engine.

Current standard authorities in issues related to LOs and education are presented in the Table 2. The standards relate to one other as is shown in the Fig. 1 (RLOs-TNQ-TAFE, 2003). Here follows a brief description of each major standard.

1. *Resource Description Framework (RDF)*: The Resource Description Framework (RDF) integrates a variety of applications from library catalogs and world-wide directories to syndication and aggregation of news, software, and content to personal collections of music, photos, and events using XML as an interchange syntax. The RDF specifications provide a lightweight ontology system to support the exchange of knowledge on the Web (RDF, 2003).

2. *XML and HTML*: XML stands for EXtensible Markup Language. XML is a markup language much like HTML. XML was designed to describe data. XML tags are not predefined in XML. You must define your own tags. XML uses a Document Type Definition (DTD) or an XML Schema to describe the data. XML was designed to carry data. XML is not a replacement for HTML. XML and HTML were designed with different goals: XML was designed to describe data and to focus on what data is, while HTML was designed to display data and to focus on how data looks. HTML is about displaying information, while XML is about describing information (XML and HTML, 2003).

Table 2

Standards for learning objects and education

General	Dublin Core	RDF		
Education	IMS	ARIADNE	EdNA	SOCCI
Learning objects	ADL-SCORM	IEEE-LOM		

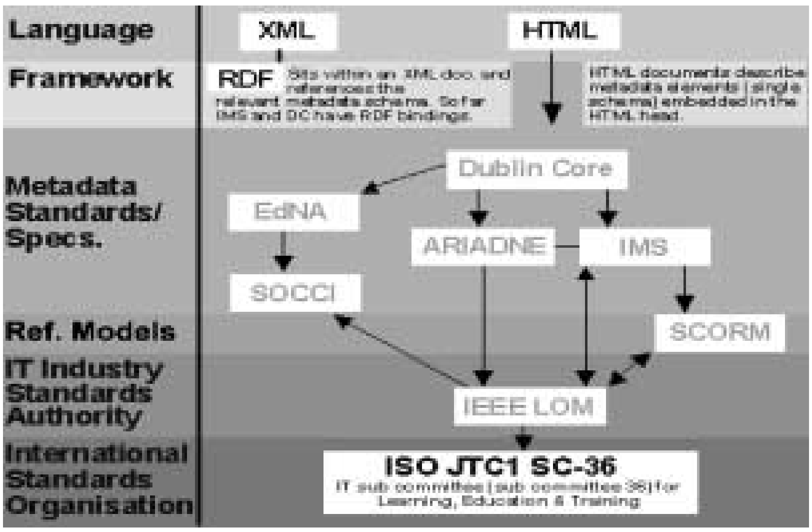

Fig. 1. The inter-relationships between education metadata standards.

3. *Dublin Core*: The Dublin Core Metadata Initiative is an open forum engaged in the development of interoperable online metadata standards that support a broad range of purposes and business models. The Dublin Core Metadata Element Set is represented by the following elements: Title, Creator, Subject, Description, Publisher, Contributor, Date, Type, Format, Identifier, Source, Language, Relation, Coverage, Rights (Dublin Core, 2003).

4. *IMS*: is being developed by the IMS Global Learning Consortium. IMS has two key goals: defining the technical specifications for interoperability of applications and services in distributed learning, and supporting the incorporation of the IMS specifications into products and services worldwide. IMS endeavors to promote the widespread adoption of specifications that will allow distributed learning environments and content from multiple authors to work together (in technical parlance, "interoperate"). Specifications are the core deliverable of IMS. Examples of such specifications are as follows: IMS Learning Design, IMS Digital Repositories, IMS Enterprise Specification, IMS Metadata Specification etc. (IMS, 2003).

5. *Ariadne*: a project for educational metadata financed within European Union FP4 program (1996–2000). Since December 1997, there has been an active cooperation between Ariadne team, IMS and LOM initiatives. The Ariadne Foundation now exploits the results of this project, on a non-commercial basis. The ARIADNE system is based on the "core" tools which allow indexing, storage, diffusion etc., of the various teaching documents. Various authoring tools are also proposed to help the teaching engineers in the creation of these documents (ARIADNE, 2003).

6. *EdNA, SOCCI* – Education Network Australia (EdNA) Online is a service that aims to support and promote the benefits of the Internet for learning, education and training in Australia. It is organized around Australian curriculum, its tools are free to Australian educators, and it is funded by the bodies responsible for education provision in Australia – all Australian governments. As an information service, EdNA Online provides two key functions: A directory about education and training in Australia and a database of web-based resources useful for teaching and learning (EdNA, 2003)

The Le@rning Federation – Scools Online Curriculum Content Initiative (SOCCI) is an initiative of State and Federal governments of Australia and New Zealand. Over the period 2001–2006, the Initiative aims to develop online interactive curriculum content specifically for Australian and New Zealand schools. The Initiative will support teachers in enhancing student learning thereby greatly improving educational outcomes for students. The project is developing systems, which will allow the input and delivery of high quality curriculum online by a range of approved content developers to an agreed set of specifications. The systems will also facilitate the breakdown of content into discrete 'objects' and the reassembly and repurposing of these to suit the particular needs of teachers and students (SOCCI, 2003).

7. *ADL-SCORM*: The Sharable Content Object Reference Model (SCORM) defines a Web-based learning "Content Aggregation Model" and "Run-Time Environment" for learning objects. The SCORM is a collection of specifications adapted from multiple sources to provide a comprehensive suite of e-learning capabilities that enable interoperability, accessibility and reusability of Web-based learning content. The work of the ADL

Initiative to develop the SCORM is also a process to knit together disparate groups and interests. This reference model aims to coordinate emerging-technologies and commercial and/or public implementations. The SCORM applies current technology developments to a specific content model by producing recommendations for consistent implementations by the vendor community. It is built upon the work of the AICC, IMS, IEEE, ARIADNE and others to create one unified "reference model" of interrelated technical specifications and guidelines designed to meet definition of data's high-level requirements for Web-based learning content. The SCORM includes aspects that affect learning management systems and content authoring tool vendors, instructional designers and content developers, training providers and others (ADL, 2003).

8. *IEEE-LOM*: The IEEE Learning Technology Standards Committee (LTSC) has been providing for the development and maintenance of the Learning Object Metadata (LOM) standard since 1997. This process has been and continues to be an international effort with the active participation on the LOM Working Group by members representing more than 15 countries. Most recently, June 12, 2002, this resulted in the first IEEE accredited standard to be completed by LTSC, the 1484.12.1 LOM data model standard. This is the first of a multi-part standard for Learning Object Metadata, which LTSC LOM is responsible for maintaining, developing and evolving. This responsibility is being fulfilled by current work on bindings of the data model standard and includes developing further versions of the data model standard (IEEE-LTSC-LOM, 2003).

The LOM standard has been well received recognized and adopted internationally, however adoption of the standard is in its early stages. For this reason, the LTSC is interested in avoiding any conditions that create the perception or reality of conflicting or multiple standards being developed for the same purpose. Furthermore, any additional metadata work should consider current implementations to avoid creating unnecessary interoperability issues.

Scope – this standard is a multi-part standard that specifies Learning Object Metadata. This part specifies a conceptual data schema that defines the structure of a metadata instance for a learning object. For this standard, a learning object is defined as any entity – digital or non-digital – that may be used for learning, education or training. For this standard, a metadata instance for a learning object describes relevant characteristics of the learning object to which it applies. Such characteristics may be grouped in general, life cycle, meta-metadata, technical, educational, rights, relation, annotation, and classification categories. The conceptual data schema specified in this part permits linguistic diversity of both learning objects and the metadata instances that describe them. This conceptual data schema specifies the data elements that compose a metadata instance for a learning object. This Part is intended to be referenced by other standards that define the implementation descriptions of the data schema so that a metadata instance for a learning object can be used by a learning technology system to manage, locate, evaluate or exchange learning objects. This part of this standard does not define how a learning technology system represents or uses a metadata instance for a learning object.

Purpose – the purpose of this multi-part standard is to facilitate search, evaluation, acquisition, and use of learning objects, for instance by learners or instructors or automated software processes. This multi-part standard also facilitates the sharing and exchange of learning objects, by enabling the development of catalogs and inventories while taking into account the diversity of cultural and lingual contexts in which the learning objects and their metadata are reused. By specifying a common conceptual data schema, this part of this standard ensures that bindings of Learning Object Metadata have a high degree of semantic interoperability. As a result, transformations between bindings will be straightforward. This part of this standard specifies a base schema, which may be extended as practice develops, e.g., facilitating automatic, adaptive scheduling of LOs by software agents.

Basic metadata structure – data elements describe a learning object and are grouped into categories. The LOMv1.0 Base Schema (clause 6) consists of nine such categories:

a) the *General category* groups the general information that describes the learning object as a whole;

b) the *Lifecycle category* groups the features related to the history and current state of this learning object and those who have affected this learning object during its evolution;

c) the *Meta-Metadata category* groups information about the metadata instance itself (rather than the learning object that the metadata instance describes);

d) the *Technical category* groups the technical requirements and technical characteristics of the LO;

e) the *Educational category* groups the educational and pedagogic characteristics of the learning object;

f) the *Rights category* groups the intellectual property rights and conditions of use for the LO;

g) the *Relation category* groups features that define the relationship between the related LOs.

h) the *Annotation category* provides comments on the educational use of the learning object and provides information on when and who created the comments;

i) the *Classification category* describes the current LO in relation to a particular classification system.

Data elements – categories group data elements. The LOM data model is a hierarchy of data elements, including aggregate data elements and simple data elements (leaf nodes of the hierarchy). In the LOMv1.0 Base Schema, only leaf nodes have individual values defined through their associated value space and datatype. Aggregates in the LOMv1.0 Base Schema do not have individual values. Consequently, they have no value space or datatype. For each data element, the LOMv1.0 Base Schema defines:

- *name*: the name by which the data element is referenced;
- *explanation*: the definition of the data element;
- *size*: the number of values allowed;
- *order*: whether the order of the values is significant, only applicable for list value data elements;
- *example*: an illustrative example.

For simple data elements, the LOMv1.0 Base Schema also defines:

- *value space*: the set of allowed values for the data element – typically in the form of a vocabulary or a reference to another standard;
- *datatype*: indicates whether the values are LangString (clause 7), DateTime (clause 8), Duration (clause 9), Vocabulary (clause 10), CharacterString or Undefined.

9. *ISO JTC1 SC-36*: Standards for Information Technology for Learning, Education and Training

Scope: Standardization in the field of information technologies for learning, education, and raining to support individuals, groups, or organizations, and to enable interoperability and reusability of resources and tools (ISO-JTC1 SC-36, 2003).

Excluded: The SC shall not create standards or technical reports that define educational standards, cultural conventions, learning objectives, or specific learning content. In the area of work of this new SC, standards and technical reports would not duplicate work done by other ISO or IEC TCs, SCs, or WGs with respect to their component, specialty, or domain. Instead, when appropriate, normative or informative references to other standards shall be included. Examples include documents on specialty topics such as multimedia, web content, cultural adaptation, and security.

10. *Other metadata standards* (Metadata standards' overview, 2003):

a. *MARC XML* The Library of Congress' Network Development and MARC Standards Office are developing a framework for working with MARC data in a XML environment. This framework is intended to be flexible and extensible to allow users to work with MARC data in ways specific to their needs. The framework itself includes many components such as schemas, style-sheets, and software tools. (MARC XML, 2003)

Uses – MARC XML could potentially be used as follows: for representing a complete MARC record in XML, as an extension schema to METS (Metadata Encoding and Transmission Standard), to represent metadata for OAI harvesting, for original resource description in XML syntax, and for metadata in XML that may be packaged with an electronic resource.

Advantages of MARC XML – Some MARC XML advantages are: the schema supports all MARC encoded data regardless of format and the MARC XML framework is a component-oriented, extensible architecture allowing users to plug and play different software pieces to build custom solutions.

Limitations of MARC XML – MARC Validations is not enforced by the schema but by external software.

b. *OAI-PMH* – the Open Archives Initiative Protocol for Metadata Harvesting provides an application – independent interoperability framework based on metadata harvesting. There are two classes of participants in the OAI-PMH framework: Data Providers administer systems that support the OAI-PMH as a means of exposing metadata; and Service Providers use metadata harvested via the OAI-PMH as a basis for building value-added services (OAI-PMH, 2003).

c. *METS* schema is a standard for encoding descriptive, administrative, and structural metadata regarding objects within a DL, expressed using the XML schema language of the World Wide Web Consortium. The standard is maintained in the Network Development and MARC Standards Office of the Library of Congress, and is being developed as an initiative of the Digital Library Federation (METS, 2003).

d. *Table of Core Metadata Elements for Library of Congress Digital Repository Development* consists of the following self-explanatory fields: access_category access_display_message access_expiration_date access_information access_rights archive_date_time archive_history archive_ID archive_next_date_time archiving_profile associated_file_name associated_file_type audio_bits_per_sample audio_channel_configuration audio_channel_information audio_sampling_frequency capture_device_ID capture_device_settings capture_entity_corporate capture_entity_individual capture_production_ID checksum_creation_date_time checksum_value creation_date_time datastream_compression deposit_date_time description_content_list description_coverage description_creator description_subject description_summary description_title dimension_horizontal dimension_vertical duration external_descriptive_information external_migration_ID external_migration_information external_record_ID external_record_type external_reproduction_ID external_reproduction_procedure feature_label file_extension handle image_bit_depth image_color_space image_orientation image_resolution intermediate_object_ID intermediate_object_use internet_media_type original_content_type parent_object_ID presentation_profile preservation_information preservation_master_ID preservation_original_information quantity_of_intermediate_objects quantity_of_terminal_objects reformatted_original_information reformatting_guidelines reformatting_information reformatting_method relationship_type relationship_value responsibility_entity responsibility_information revision_date_time segment_type segment_value serial_part serial_relationship size use video_data_rate video_frame_rate (Library of Congress Core Metadata Elements, 2003).

5. Critical Overview of Instructional Digital Libraries on the Web

Digital libraries populated with learning objects, labeled with metadata, have become popular tools in the creation of educational applications. Unfortunately, most actual DLs do not currently provide methods or support for recombining and embedding discovered learning objects within new instruction models and curricula. While many advances have been made in the creation of DLs, there is considerable room both for improving how learning objects are accessed/re-used by the educators and learners and for enhanced support in design of instruction and implementation of sound (built according with viable instruction theories and best practice) instructional systems.

We have performed an extended search on the web using different search engines and we have discovered that there are two classes of accessible instructional digital libraries: large initiatives that are continuously developing comprehensive DLs for many areas of arts, and sciences (including technical), and small specific DLs built as a support for particular purposes. From the former category we mention:

- SMETE that is a vast dynamic online library and portal of services that "opens up the worlds of science, maths, engineering and technology education to teachers and students anytime, anyplace" (SMETE 2003);

- GEM which provides educators for "quick and easy access to thousands of educational resources found on various federal, state, university, non-profit, and commercial Internet sites" (GEM 2003);

- MERLOT which is "a free, open resource designed primarily for higher education" (MERLOT 2003);

- NEEDS that is "a digital library of learning resources for engineering education" (NEEDS 2003);

- ERIC that is "a nation-wide information network designed to provide access to education literature that contains more than one million bibliographic records of journal articles, research reports, curriculum and teaching guides, conference papers, and books" (ERIC, 2003).

The later category is represented by many subject-oriented digital libraries as (see references): Education Instructional Library – American Society for Microbiology, Pathology Education Instructional Resource, Teaching American History in Louisiana, Mathematical Sciences Digital Library – Mathematical Association of America, BIOME – a searchable catalogue of resources for health and life sciences etc.

Both types of digital libraries have in common the fact that they offer access (browse/search) to large collections of digital (hypermedia) documents (viewed as learning resources), and that they offer little support for instructional design and for construction of instructional systems. Thus, very few of them provide some links to general scientific papers about instruction issues or to some sample curricula.

The most notable effort in this direction is ARIADNE (Alliance of Remote Instructional Authoring and Distribution Networks for Europe), a "European suite of projects, which created tools and methodologies for producing, managing and reusing computer-based pedagogical elements and telematics supported training curricula". This project had developed a "truly European Knowledge Pool" of instruction resources (learning objects, curricula etc.). Unfortunately, in our opinion, despite the fact that the project had built a valuable set of methodologies and support tools for all the actors involved in various instructional processes, its results have not been used to their best potential and, consequently, the knowledge pool is rather poor in resources. Simple searches (that are fee-free, unlike the use of the rest of the ARIADNE resources, which may be used for a symbolic fee for educational users) for keywords like "memory", "cache", "round robin" for Operating Systems sub-domain, or "sort", "search", or "complexity" against Algorithmics sub-domain, had failed in founding any learning resources (ARIADNE, 2003).

6. One Possible Solution: Scholnet – a European Project for Developing a DL Testbed to Support Networked Scholarly Communities

The Scholnet project had as its aim the building of a DL infrastructure for supporting communication and collaboration among networked scholarly communities. In addition to the provision of standard DL capabilities for information acquisition, description, archiving, access, search, and dissemination, this infrastructure will provide support for non-textual data types, hypermedia annotation, cross-language search and retrieval, and personalized information dissemination (Scolnet, 2003). From the technical point of view, Scholnet has been built by augmenting an existing federated DL system, OpenDLib, with modules that implement non-standard DL services. The Scholnet infrastructure will be "open", i.e., it will allow an incremental service extensibility to meet the specific needs of the different scholarly communities. Scholnet will be used to create a DL infrastructure serving the Working Groups of the European Consortium for Informatics and Applied Mathematics.

The aim of Scholnet has been to build a new generation DL infrastructure that can be used to easily create digital libraries that enable the immediate dissemination and accessibility of technical documentation (and the underlying ideas) within a globally distributed multilingual community. This infrastructure will contribute to the creation and diffusion of a new model for scholarly production. The Scholnet infrastructure will provide not only the traditional DL services but also support for non-textual documents, hypermedia annotation, cross-language search and retrieval, and personalized information dissemination. The Scholnet infrastructure will be built as an open federation of interoperable services, possibly distributed and replicated on different servers. This architectural choice will allow an incremental service extensibility that will permit to satisfy the specific needs of the different scholarly communities.

The Scholnet infrastructure has been designed for scholarly communities working in different domains. A number of Scholnet infrastructure testbeds will be created by instantiating the Scholnet system for different communities. Among these, the ERCIM Working groups (ERCIM, 2003) extended by the members of the DELOS Network of Excellence on DLs (DELOS, 2003) and the Clarity project language information community (Clarity, 2003). The corresponding community will feed each testbed with the documents in use. These documents consist of textual documentation, such as technical reports, project deliverables, workshop proceedings, and multimedia composite documents, such as synchronized videos and slides of seminars, tutorial, demos, etc. The Scholnet DL testbeds will enable the immediate dissemination and accessibility of technical documentation (and the underlying ideas) within their target scholarly communities. They will be actively used by the members of the communities in the every-day individual and/or collaborative tasks and will be regularly updated and extended. The instantiated infrastructures will contribute to the creation and diffusion of a new model for scholarly production.

The innovation introduced by Scholnet is twofold. Presently, most of the DLs are implemented as ad-hoc services created to disseminate specific collections of documents. Scholnet, instead, proposes a generic DL system with very adaptable archive functionality capable of working with a wide range of documents types, structures, media, etc. This system allows the creation of digital libraries by simply instantiating it and then loading its repositories with the appropriate content. The current DLs offer the same functionality of the traditional libraries on digital documents. Scholnet implements a system for a new generation of digital libraries, which are not only mechanisms for the dissemination of content but also support the communication and collaboration among scholars.

7. Another Possible Solution: Using Non-Authoritative Metadata as Viewed by Wiley

Many current efforts to create standard metadata structures that facilitate the discovery and instructional use of learning objects recommend a single, authoritative metadata record per version of the learning object. However, as Wiley argues in this paper, a single metadata record – particularly one with fields that emphasize knowledge management and technology, while evading instructional issues – provides information insufficient to support instructional utilization decisions. To put learning objects to instructional use, users must examine the individual objects, forfeiting the supposed benefits of the metadata system. As a solution, Wiley and his colleagues propose a system that includes multi-record, non-authoritative metadata focused on the surrounding instructional context of learning objects (Wiley, 2000c; Recker and Wiley, 2001a, 2001b, 2001c).

The Internet and its application software (e.g., the Web) have become the de-facto resource access and distribution system of the new millennium. However, the Web lacks the standardized structures and typologies found in robust information retrieval systems. Its distributed nature precludes implementing filtering and reviewing conventions typically provided by libraries, reviewers, and publishers. Moreover, a recent study suggests that the coverage of Web content by search engines is continually decreasing, with no more than 16% coverage by any one engine. At the same time, the study shows that bias in coverage is increasing. The full-text approach to searching has also become increasingly ineffective due to the rise in non-textual information online. As a result, the search engine approach generally suffers from low precision and recall.

To address these problems, much recent research has focused on building Internet-based digital libraries, containing vast reserves of information resources. Within educational applications, a primary goal of these libraries is to provide users (including teachers and students) a way to search for and display digital learning resources commonly called 'learning objects'. As part of these efforts, researchers are developing digital library cataloging systems. Much like labels on a can, these labels, or data elements, provide descriptive summaries intended to convey the semantics of the object. Together, the data elements usually comprise what is called a metadata structure. Thus, in typical educational digital library applications, learning objects are stored and labeled with a metadata record. This metadata record usually contains basic information about the object. This may include, for example, technical requirements, rights management, and author demographics. Because of their status as official data descriptors, this is called *authoritative* *metadata*. Metadata structures are searchable and thus provide a means for discovering, sharing, and reusing learning objects, even when these objects are non-textual.

Wiley and his co-authors examine key assumptions underlying the design of an educational digital library coupled with a metadata structure. In particular, they analyze the fundamental notion that a LO can be disassociated from its original learning context, effectively described with metadata elements, and then discovered via these descriptions in order to be used or re-used in a new learning context. In short, they paper analyzes the extent to which 'authoritative' metadata support discovery and the instructional reuse of LOs. As they explain, their analysis suggests that in addition to 'authoritative' meta-information, a metadata structure must also incorporate what they call *non-authoritative metadata*. This form of metadata captures the 'embedding' context of a learning object within instruction. For example, these data elements can describe how a learning object was reused, its juxtaposition to other learning objects, and its usefulness in particular instructional contexts. The metadata can also describe the community of users from which the learning object is derived. They argue that this kind of metadata is critical in supporting effective discovery and re-use of learning objects for instructional purposes.

The distinction between authoritative and non-authoritative is primarily based on the differences between the persistent and potentially falsifiable (authoritative) aspects of a learning object (e.g., file size) and the (non-authoritative) context of learning object use and re-use (e.g., its value or usefulness within a particular instructional situation). We need to specifically address and capture both the former and latter properties in order to support learning object reuse. They point out also that authoritative metadata is generally contributed by the author or authorized catalogers. Non-authoritative metadata, on the other hand, is more likely to be contributed by users of LOs.

They believe also that capturing and storing such non-authoritative metadata is especially amenable to the application of a recent information filtering technique, called *collaborative filtering*. In particular, the approach supports discovery and automatic filtering and recommendation of relevant learning objects in a way that is sensitive to the needs of particular communities of users interested in teaching and learning. An additional benefit of this approach is that it allows a user to locate other users (students or instructors) that share similar interests for further communication and collaboration.

Altered Vista is a web based collaborative filtering tool that is geared toward educational web sites (both for students as well as teachers) and that has been built by Wiley's team. In its current form, users explicitly submit a detailed rating form for web sites and then request recommendations that are generated using a neighborhood based correlation approach. The system has gone through several user trials and data for the most recent of these is available for download on the project site (Alteredvista, 2002). Preliminary findings suggest that this particular user population tends to rate with a ceiling effect. While this results in extremely accurate predictions, these predictions do not outperform a simple non-personalized community average.

The Instructional Architect (IA) is another system that authors are currently designing and implementing, which incorporates their ideas based on non-authoritative metadata structures (Instructional Architect, 2002). IA is a program designed to help the user to handle existing instructional resources from digital libraries in order to create engaging and interactive educational web pages. Current DL partners are: SMETE Open Federation (SMETE, 2003), National Library of Virtual Interactive Mathematics (NLVIM, 2002), and National Science, Mathematics, Engineering, and Technology Digital Library (NSDL, 2002).

The system is comprised of a suite of four tools that function together to facilitate the discovery, selection, and instructional use of learning objects stored within a digital library. These are: Discovery, Presentation-Inspection-Recommendation, Combination, and Reflection Tool. The function of each of these tools and the role of non-authoritative metadata are described below.

The *Discovery Tool* provides the user a way to initiate a search for one or more learning objects. The tool operates in one of two modes. In simplex mode, the user performs a search against a digital library. An initial test-bed digital library is the NSF-funded SMETE library, (SMETE, 2003), using a simple interface to the library's native search tool. The results from this search are passed across the network to the Discovery tool, which then interprets the results and passes them to the Prediction, Inspection, and Recommendation Tool (PIRT) (described below). In duplex mode, the user initiates the learning object search from within the Discovery Tool itself. The tool then remotely queries one or more digital libraries, interprets the results, stores them, and passes them to the PIRT. Duplex mode can provide several features not necessarily available in simplex mode, including federated searching across several digital libraries and simultaneous searching against the Instructional Architect's 'non-authoritative' database of collaborative filtering and learning object usage information. This functionality is similar to that of a meta-search engine that submits a single query to multiple search engines and organizes the cumulative results for the user.

Presentation, Inspection, and Recommendation Tool (PIRT). The primary function of this tool is to enable users to examine candidate learning objects returned from a search of the digital library. PIRT provides support to users in several ways. First, it presents the learning objects to the user in a suggested inspection order. That is, when the user searches the digital library for resources, instead of seeing a long list of results in a pseudorandom order, the tool presents the list of candidate learning objects in an order matched to estimated desirability and the user's preferences. PIRT also allows users to preview candidate learning object within the context of the tool. The algorithm underlying the inspection order is based upon the user's search criteria, user's preferences, and metrics from prior usage of the objects. These metrics are based on a model derived in prior authors' research. In particular, they showed that access to an online, digital object is strongly correlated with the recency and frequency of prior object usage. The user then selects learning objects for further consideration, indicating a preference for objects. The tool uses this selection information to recommend additional learning objects that may be relevant to the user. As previously described, the algorithm underlying these recommendations is based upon research in collaborative information filtering. Specifically, it uses a nearest-neighbor approach to compare information regarding objects previously used together by the user's neighborhood and the group of objects a user has selected in order to recommend additional objects that may be of interest. Eventually the user selects some subset of the learning objects returned from both the search and recommender algorithm for utilization. Information about these objects is passed to the Combination Tool.

The *Combination Tool* allows the user to contextualize the learning objects selected by PIRT. This tool presents the user with the opportunity to sequence the LOs as they will appear in the online instruction. For the combined set of learning objects to be more than a digital slide show, they must be contextualized in some manner appropriate to the target learning context. The user can also provide context for the sequenced objects, through the provision of explanatory and transitional text, from within the Combination Tool. The graphic design or screen layout of the objects and surrounding text are controllable through selection of one of a set of user extensible interface templates. Note that learning objects as defined by the LTSC/LOM working group are generally cases of instructional media. As such, the Combination Tool contains an instructional design coach based on Heinich, Molenda, Russell, and Smaldino's ASSURE model of instructional media utilization. This coach does not impose an instructional approach or theory upon users; instead, it provides optional, just-in-time support and guidance to users concerning the effective use of media. The outcome of interaction with the Combination tool is a piece of online instruction, consisting of learning objects and contextualizing information. This instruction can then be downloaded for future use.

The *Reflection Tool* is used in a post-hoc manner, having two key functions. First, the tool is used to capture explicit user comments on the effectiveness, ease, and manner in which the various learning objects selected were used. Thus, the tool can capture the users' context in their use of learning objects. These user recommendations are stored in a non authoritative metadata database, along with implicit data concerning the use of learning objects. Using collaborative filtering techniques, such metadata are used to facilitate future recommendation of learning objects from within the PIRT. Secondly, as previously described, using similar techniques, these non-authoritative metadata records can be used to match people whose usage and recommendations correlate strongly. As these clusters take shape, the Reflection Tool can notify users about their similarities with other members in these emerging communities. Using standard Internet communication tools, users can locate like-minded users to collaborate, communicate, and form new online communities.

Conclusion and discussion – a single authoritative metadata record can describe a learning object in general (authoritative) terms such as its technical requirements, rights management, and author demographics. However, Wiley and his co-authors argue that records of this type are insufficient to represent the range of information necessary to reuse learning objects in the context of instructional design. Decisions regarding the use and combination of instructional media (which most learning objects qualify as) are decisions about the manner in which to contextualize the media. Therefore, without representing information regarding contextualization, metadata cannot fully support the instructional use of learning objects. They have showed how a particular learning object might have multiple metadata records; these may be referenced within multiple contexts. The customizable metadata structure also enables what they have called non-authoritative data elements to be included. These better allow the context of use and re-use of particular learning objects to be described. This supports the discovery of learning objects in a way that is sensitive to the needs of particular communities of users. Moreover, the collaborative filtering approach also supports the automatic recommendation of relevant learning objects. It also allows a user to locate other users that share similar interests for further communication and collaboration.

They have also presented a partial catalog of the benefits that could be realized through the execution of the approach described. It described a suite of tools that rely upon the approach in order to make such contextual information available to DL patrons during searching and discovery, while supporting them during the process of instructional design. These capabilities and user services, we believe, are critical to the success of a learning object digital library.

8. Conclusions

In this paper we presented a perspective on learning objects' and instructional digital libraries' world as it can be seen from the points of view a user, an instructional designer and an educator. We have approached this world trying to look at it as a user who wants to find some instructional resources that correspond to some particular learning goals, as an instructional designer who intends to build instructional applications using the most appropriate learning resources available in open instructional design digital libraries, and, lastly, as an educator who is concerned with providing high-quality education for its students.

We consider Wiley's definition as more appropriate for a working definition, without ignoring the potential of IEEE-LTSC-LOM detailed definition, especially for integrated software instructional applications that is better to conform to this definition for interoperability and reuse issues.

Object oriented approach for learning is very valuable and has important benefits for instruction that range from flexibility, easiness of updates, searches and content management, to customization, reusability, interoperability and meaningful learning. Well-designed learning objects are very valuable assets for instruction.

Metadata standards provide for increased interoperability between various instructional applications and, therefore, for building complex instructional systems and environments in the evolving Information Society. In our opinion, instructional digital libraries will play an active and important role in this regard, by offering open access to all kind of instructional resources that range from common learning objects, to syllabi and curricula, instructional applications and systems.

We consider that only communities of users supported by specific software applications and instructional digital libraries can provide for using meaningfully of available digital learning resources, taking into consideration that intelligent systems for searching and finding exactly what a particular user wants are only in their early life. By means of non-authoritative metadata, these intelligent systems can also improve their hit rate.

Involving the conscious user in the process of making sense of the huge quantity of learning resources to be available on the web, is, in our view, the only straightforward way to having fast access to the most appropriate (instructional) resource that is needed for a particular (educational) aim.

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M.-M. Vladoiu got her MSc in the Department of Computer Science of Polytechnic University of Bucharest, Romania, in 1991. Since then, she has been with the Department of Informatics, PG University of Ploiesti (UPG), Romania, now being an assistant professor there. In 2002, she had got her doctoral degree in multimedia databases, with a thesis about a new multimedia object model. During the PhD work, she had the opportunity to specialize in object-oriented databases at University of Magdeburg (Germany), within the TEMPUS program framework (1998). In 2002, she had also been awarded with an ERCIM (European Research Consortium for Informatics and Mathematics) post-doctoral fellowship, to be carried on at Department of Computer and Information Science, Norwegian University of Science and Technology, Trondheim, Norway. Her main research interests are e-learning, instructional digital libraries, and reflective e-instruction.

Mokomosios skaitmeninės bibliotekos ir mokomieji objektai

Mihaela-Monica VLADOIU

Straipsnyje supažindinama su standartinių mokomųjų objektų (anglų k. learning objects) koncepcija, atskleidžiamos įvairios su tuo susijusios prieštaros, diskusijos, bandoma suformuluoti darbinį apibrėžimą. Vėliau aptariamos mokomųjų objektų savybės, supažindinama su objektinio mokymo bei mokymosi privalumais, nagrinėjami argumentai, ar reikia vartoti mokomuosius objektus bei galiausiai nubrežiamos tam tikros kokybės standartų šiems objektams gairės. Taip pat trumpai pristatoma mokomųjų objektų tipų taksonomija, nagrinėjami meta duomenų standartai, kurie gali būti naudojami kaip mokomieji objektai, bei aptariama, kaip visa tai susiję tarpusavyje. Straipsnyje pateikiama mokomųjų skaitmeninių bibliotekų, esančių žiniatinklyje, apžvalga. Straipsnio pabaigoje suformuluojami galimi sprendimai, kaip žiniatinklyje esančius mokomuosius objektus galima panaudoti prasmingiau. Siūlomos dvi išeitys: arba steigti iš tiesų naudingas visuomenines skaitmenines bibliotekas, arba pagalbon pasitelkti įvairius, dažniausiai nesisteminius meta duomenis tam, kad šie mokymosi šaltiniai būtų rasti. Straipsnio autorės nuomone, vienintelis efektyvus būdas greitai pasiekti žiniatinklyje esančius tinkamiausius mokomuosius šaltinius, reikalingus konkrečiai užduočiai atlikti, – tai gebėjimas įtraukti sąmoningus vartotojus į šių šaltinių kūrimo procesą.