

# Learning objects need badly Digital Libraries support

## E-learning and (Instructional) Digital Libraries

### I. What are Learning Objects?

According with IEEE-LTSC-LOM standard which has become a de facto standard for learning object metadata (Full Name of Standard: Standard for Information Technology -- Education and Training Systems -- Learning Objects and Metadata; it has been developed within IEEE 1484.12 Learning Object Metadata Working Group of IEEE Learning Technology Standards Committee - LTSC), a learning object can be defined **as any entity, digital or non-digital, that may be used for learning, education or training.**

[http://ltsc.ieee.org/doc/wg12/LOM\\_1484\\_12\\_1\\_v1\\_Final\\_Draft.pdf](http://ltsc.ieee.org/doc/wg12/LOM_1484_12_1_v1_Final_Draft.pdf) (June 12, 2002)

This rather broad definition has been actively criticized by an important author, the most important it seems, in learning objects issues: David Wiley from Utah State University.

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Short introduction card for D. Wiley:

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His research interests include learning objects, mediated action, self-organization and autocatalysis, peer-to-peer networks, collaborative learning, open source culture, and intellectual property law. The main thrust of his research agenda is extending access to educational opportunity to everyone who wants it. This currently manifests itself in an interest in providing scalable learning environments that are rich with human interaction. His NSF/CAREER grant centers around understanding how learning happens in large, decentralized, self-organized communities online -- and leveraging this understanding to design and build learning environments that are both **scalable and social**.

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1. **The Instructional Use of Learning Objects** (online) - a book that tries to go beyond the technological hype and connect learning objects to instruction and learning; Chapter: Connecting learning objects to instructional design theory: A definition, a metaphor, and a taxonomy (<http://reusability.org/read/>).

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 learning objects: 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, learning objects 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 learning objects can collaborate on and benefit immediately from new versions. These are significant differences between learning objects and other instructional media that have existed previously.

Supporting the notion of small, reusable chunks of instructional media, Reigeluth and Nelson (1997) suggest that when teachers first gain access to instructional materials, they often break the materials down into their constituent parts. They then reassemble these parts in ways that support their individual instructional goals. This suggests one reason why reusable instructional components, or learning objects, may provide instructional benefits: if instructors received instructional resources as individual components, this initial step of decomposition could be bypassed, potentially increasing the speed and efficiency of instructional development.

To facilitate the widespread adoption of the learning objects approach, the Learning Technology Standards Committee (LTSC) of the Institute of Electrical and Electronics Engineers (IEEE) formed in 1996 to develop and promote instructional technology standards. Without such standards, universities, corporations, and other organizations around the world would have no way of assuring the interoperability of their instructional technologies, specifically their learning objects.

Their 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 the universe, since any of these could be "referenced during technology supported learning." 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.

The Learning Technology Standards Committee definition seems too broad to be useful, since most instructional technologists would not consider the historical event "the war of 1812" or the historical figure "Joan of Arc" to be learning objects. At the same time, the creation of yet another term only seems to add to the confusion. While the creation of a satisfactory definition of

the term learning object will probably consume the better part of the author's career, a working definition must be presented before the discussion can proceed.

So, the author proposes, as a working definition for a learning object: **any digital resource that can be reused to support learning**. 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 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 learning objects as defined by the LTSC), making issues of compatibility of learning object as defined within this chapter and learning object as defined by the LTSC explicit. The proposed definition captures what the author feels to be the critical attributes of a learning object, "reusable," "digital," "resource," and "learning," as does the LTSC definition. With that compatibility made explicit, the proposed definition differs from the LTSC definition in two important ways.

First, the definition explicitly rejects non-digital (by dropping the word and dropping the idea of a learning object being simply "reference"-able) and non-reusable (by dropping the phrase "used or" which seems to imply the acceptance of single use) resources. The definition of learning object presented in this chapter does not include actual people, historical events, books (in the traditional sense of the term), or other discrete, physical objects. The definition also drops the phrase "technology supported" which is now implicit, because all learning objects are digital.

Second, the phrase "to support" has been substituted in place of "during" in the LTSC definition. Use of an object "during" learning doesn't connect its use to learning. The LTSC definition implies that nothing more than contiguity of an object's use and the occurrence of learning is sufficient, meaning that a banner advertisement atop an online course web page would be a legitimate learning object. The definition adopted for this chapter emphasizes the purposeful use (by either an instructional designer, an instructor, or a student) of these objects to support learning.

Armed with a working definition of the term learning object, the discussion of the instructional use of learning objects can proceed.

**2. Reusable Learning Objects** - a project at Tropical North Queensland (TNQ) - Technical and Further Education (TAFE) Institute, Australia (<http://www.tnqit.tafe.net/RLO/definition.htm>).

To the question **What are the learning objects**, the TNQ team answers:

- 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.
- Self-contained - each learning object can be taken independently.
- 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.
- Able to be aggregated - learning objects can be grouped into larger collections of content, including traditional course structures.
- Tagged with metadata - every learning object has descriptive information allowing it to be easily found by a search.
- Learning Objects let you have learning that is:
  - Just enough - if you need only part of a course, you can use the learning objects you need.
  - Just in time - learning objects are searchable, you can instantly find and take the content you need.
  - Just for you - learning objects allow for easy customization of courses for a whole organization or even for each individual.

### **A Learning Object must be:**

**Reusable:** 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.

**Standalone:** 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.

**Discoverable:** Objects must be able to be found. Learning Objects 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.

**Granularity:** 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.

**Interoperable:** 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 to standards.

**Instructional value:** In order to be defined as a Learning Object there must be some intrinsic instructional value. A Learning Object is not just a Knowledge or Information object.

**The object approach - benefits:**

**Flexibility:** Material 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 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 approach allows organisations to set specifications regarding the design, development and presentation of Learning Objects based on organisational 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:** 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.

**What can RLOs do for us:**

| <b>For developers and organizations:</b>   | <b>For learners and organizations:</b>  |
|--|---|
| <ul style="list-style-type: none"><li>• Shorter development cycles</li><li>• Cheaper development of online resources</li><li>• Ease of updates</li><li>• Interoperability Assessment</li></ul> | <ul style="list-style-type: none"><li>• Flexibility</li><li>• Customization</li><li>• Personalization</li><li>• Miniaturization</li><li>• Aid Just-in-time training</li></ul> |

What they can **also** do for us, however is land us in court! 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 AShareNet, GEM and MERLOT.

In Learning Object speak **granularity** is a common term. Consideration of the granularity of an object can help with an understanding of the difficulty of arriving at a definition. Bear in mind that there is no real common consensus as to the definition of an RLO or what level of granularity constitutes one.

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.

The IMS project 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.

What is certain that the level can not be so small as to lose meaning to any one at all (is a letter of the alphabet an RLO??) 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 learning object level.

### **Interoperability and Usability - A Scenario (not too far from home)**

Suppose you 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, 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). Without them, anyone with a significant investment in either content or a learning system is locked into that particular content or system. Without them, 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. Without them, 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.

**Pros and Cons for RLOs:**

|                         | <b>PROS</b>   | <b>CONS</b>   |
|-------------------------|---|---|
| <b>Production Costs</b> | 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.   |
| <b>Flexibility</b>      | As more and more standards based learning objects become available, increased choice will translate into more flexibility for designers.  | Using standards based learning objects restricts the scope of learner information that is accessible by content if total interoperability is maintained.                  |
| <b>Pedagogy</b>         | Learning objects fit nicely into many ISD theories. Instructional templates can be created with slots for specific types of learning objects. Learning Objects 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 learning objects. |
| <b>End User Cost</b>    | 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 learning object approach may be significant.   |
| <b>Industry Support</b> | 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.  |

## RLO attributes

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

- 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 (such that it can be adapted 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 repurposed within a different visual schema without losing the essential value or meaning of the text, data or images.

## Quality standards

The Wisconsin Online Resource Centre Interactive Learning Objects quality standards are a useful guideline (<http://www.wisc-online.com/index.htm>):

| <b>QUALITY STANDARDS: THE LEARNING OBJECT...</b>  |
|---|
| 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 (AAHE).*  |
| Applies appropriate Learning College Principles (O'Banion).**   |

## II. Taxonomy of learning object types (<http://wiley.ed.usu.edu/docs/dissertation.pdf>)

All learning objects 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 learning object different from another. This section introduces a taxonomy of learning object types with which the designer should familiarize oneself. This section is included as reference, and does not contain any design prescriptions. Design prescriptions based on the information included in the taxonomy and discussion are included in other sections. This taxonomy identifies five types of learning objects. Examples of these five object types are given below, followed by the taxonomy, which explicates their differences and similarities:

- *Single-type* - For example, a JPEG of a hand playing a chord on a piano keyboard.
- *Combined-intact* - For example, a video of a hand playing an arpeggiated chord on a piano keyboard with accompanying audio.
- *Combined-modifiable* - For example, a web page dynamically combining the previously mentioned JPEG and QuickTime file together with textual material, on-the-fly.
- *Generative-presentation* - 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* - For example, an EXECUTE instructional transaction shell (Merrill, 1999), which both instructs and provides practice for procedures, for example, the process of chord root, quality, and inversion identification.

Distinguishing between the learning object 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 learning objects exists or not).

Table 1 presents the taxonomy previously mentioned. The purpose of the taxonomy is to differentiate possible types of learning objects available to designers for use in instructional design. This taxonomy is not exhaustive in that it includes only learning object types that facilitate high degrees of reuse. Other types of learning objects that hamper or practically prevent reuse, (e.g., an entire digital textbook created in a format that prevents any of the individual media from being reused outside of the textbook context), have been purposefully excluded in order to discourage their creation. The taxonomy's characteristics' values (such as High, Medium, and Low) are purposefully fuzzy, as the purpose of this taxonomy is solely to facilitate inter-object comparison (i.e., it is norm referenced), and not to provide independent metrics for classifying learning objects out of context, such as file size in kilobytes (i.e., it is not meant to be criterion referenced). Table 1 is followed by a more in depth discussion of each of the characteristics or critical attributes of learning objects and the learning object types themselves.

Table 1. Taxonomy of Learning Object Types.

| Learning Object Characteristic       | Single-type Learning Object | Combined-intact Learning Object          | Combined-modifiable Learning Object                              | Generative-presentation Learning Object | Generative-instructional Learning Object                                  |
|--------------------------------------|-----------------------------|--|--|---|---|
| Number of elements combined          | One                         | Few                                      | Many   | Few - Many                              | Few - Many  |
| Type of objects contained            | Single                      | Single, Combined-intact                  | All  | Single, Combined-intact                 | Single, Combined-intact, Generative-pres                                  |
| Reusability of component objects     | (not applicable)            | Low                                      | High   | High                                    | High  |
| Common function                      | Exhibit, display            | Pre-designed instruction or practice     | Pre-designed instruction and / or practice                       | Exhibit, display                        | Computer-generated instruction and / or practice                          |
| Extra-object dependence              | No                          | No                                       | Yes  | Yes / No                                | Yes   |
| Type of logic contained in object    | (not applicable)            | None, or answer sheet based item scoring | None, or domain-specific instructional and assessment strategies | Domain-specific presentation strategies | Domain-independent presentation, instructional, and assessment strategies |
| Potential for inter-contextual reuse | High                        | Medium                                   | Low  | Low                                     | High  |
| Potential for intra-contextual reuse | Low                         | Low                                      | Medium   | High                                    | High  |

**Learning object characteristics** The characteristics in Table 1 are described in more detail below.

- *Number of elements combined* - Describes the number of individual elements (such as video clips, images, etc.) combined in order to make the learning object.
- *Type of objects contained* - Describes the type of objects that may be combined to form a new learning object.
- *Reusability of component objects* - Describes the degree of ease with which constituent objects may be individually accessed and reused.
- *Common function* - Describes the manner in which the object is generally used.
- *Extra-object dependence* - Describes whether the object needs information (such as location on the network) about learning objects other than itself.
- *Type of logic contained in object*- Describes the function of algorithms and procedures within the object.
- *Potential for inter-contextual reuse* - Describes the number of different instructional contexts in which the learning object may be used, that is, the object's potential for reuse in different content areas or domains.
- *Potential for intra-contextual reuse* - Describes the number of times the object may be used within the same content area or domain.

**Learning object type definitions** The five types of learning objects have been exemplified and their characteristics have been described. While the creation of strict definitions for these types is a career's work in progress (as with the definition of learning object itself), the author's current best thinking with regard to definitions of each type is captured below.

- *Single-type* - An individual digital resource uncombined with any other, the Single-type learning object is generally a visual (or other) aid that serves an exhibit or example function.
- *Combined-intact* - A small number of digital resources combined at design time by the object's creator, whose constituent learning objects are not individually accessible (recoverable) from the Combined-intact object itself. The Combined-intact learning object may contain 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 learning objects should be single purpose, that is, they should provide either instruction or practice.
- *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 learning objects are directly accessible (recoverable) from the Combined-modifiable object. Combined-modifiable learning objects frequently combine related instructional and practice-providing Combined-intact and Single-type objects in order to create a complete instructional sequence.
- *Generative-presentation* - Logic and structure for combining or generating and combining lower-level learning objects (Single-type and Combined-intact types). (such as "identify chords"). Generative-presentation learning objects 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 learning objects must be able to pass messages to other objects with assessment logic when used in practice or testing). While Generative-presentation learning objects 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).
- *Generative-instructional* - Logic and structure for combining learning objects (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 learning object is high in both intra-contextual and inter-contextual reusability.

### III. Metadata standards for Learning Objects

**What is Metadata?** 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.

**Where is it found?** 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.( If you click on view source in the browser, you will see the dublin core metadata for this 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**).

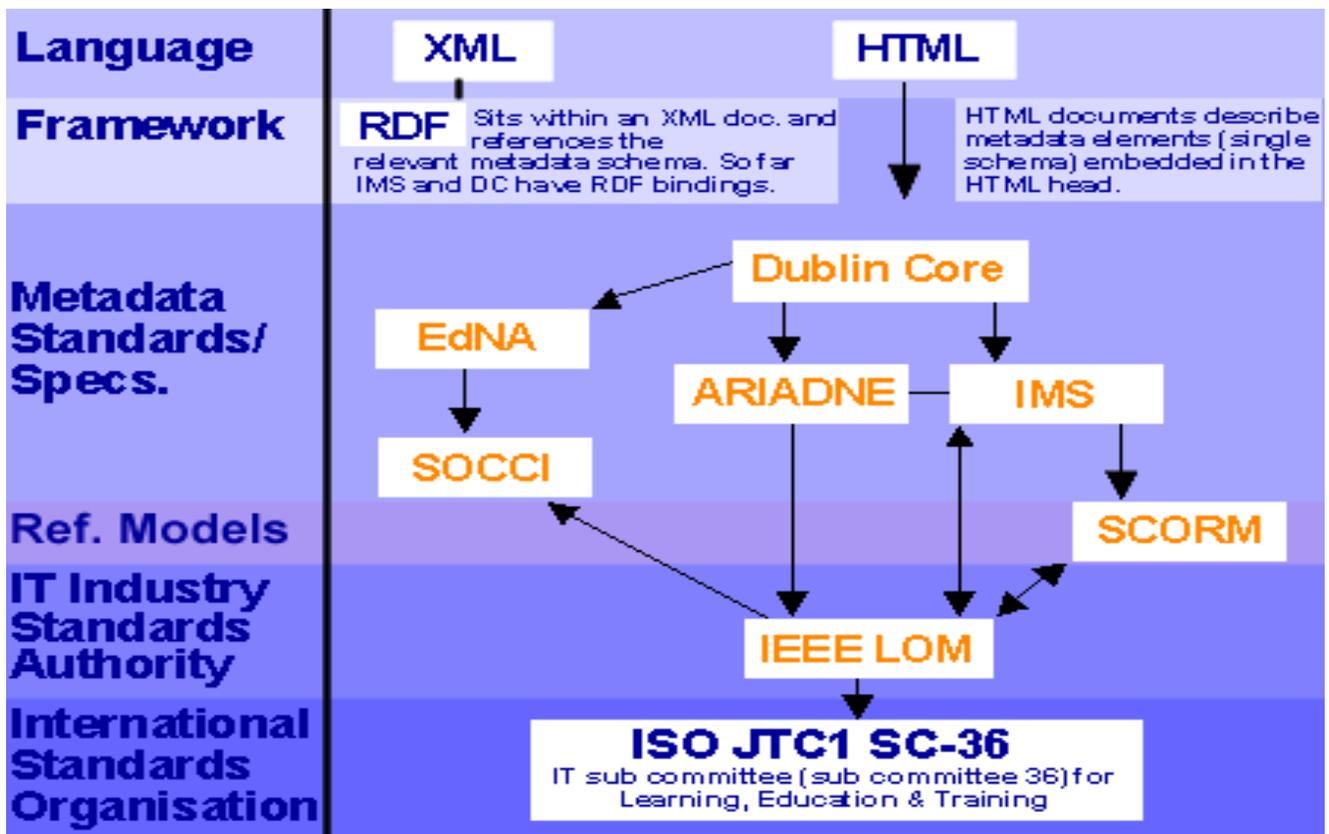
**What does it consist of?** Metadata consists of a set of elements or fields that describe the resource, such as author, date, title etc. In the case of a learning object such as a web video or animation, this metadata also needs to hold information about the file format, size, software required etc. 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**.

**Why Standards?** 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:**

|                         |             |          |      |       |
|-------------------------|-------------|----------|------|-------|
| <b>General</b>          | Dublin Core | RDF      |      |       |
| <b>Education</b>        | IMS         | ARIADNE  | EdNA | SOCCI |
| <b>Learning objects</b> | ALD-SCORM   | IEEE-LOM |      |       |

How the standards relate to one other:



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 (<http://www.w3.org/RDF/>).

## 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 (<http://www.w3.org/XML/>).

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 (<http://dublincore.org/>).

4. Ariadne: a project for educational metadata financed within EU FP4 program (1996-2000). Since December 1997 there has been an active cooperation between Ariadne team and IMS and LOM initiatives. The results of this project are now exploited, on a non-commercial basis by the AriadneFoundation (<http://www.ariadne-eu.org/>). The ARIADNE system is based on the "core" tools which allow indexing, storage, diffusion..., of the various teaching documents. Various authoring tools are also proposed to help the teaching engineers in the creation of these documents.

5. *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 Meta-data Specification* etc. (<http://www.imsglobal.org/>)

#### 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. (<http://www.edna.edu.au/>)

The Le@rning Federation - Schools 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. (<http://www.thelearningfederation.edu.au/tlf/>)

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 DoD'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. (<http://www.adlnet.org/>)

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.

The IEEE 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 take current implementations into consideration 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, educational, 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 which 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 learning objects 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 learning object.
- 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 learning object.
- g) The *Relation* category groups features that define the relationship between the learning object and other related learning objects.
- h) The *Annotation* category provides comments on the educational use of the learning object and provides information on when and by whom the comments were created.
- i) The *Classification* category describes this learning object 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 data elements with list values, see clause
- 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.

(<http://ltsc.ieee.org/wg12/>)

### 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 training to support individuals, groups, or organizations, and to enable interoperability and reusability of resources and tools (<http://jtc1sc36.org/>).

**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. Others (<http://www.mun.ca/library/cat/standards.htm> last updated: 16.02.03):

a. *MARC XML* The Library of Congress' Network Development and MARC Standards Office is 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. (<http://www.loc.gov/standards/marcxml/>)

## 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 (referred to as the OAI-PMH in the remainder of this document) 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 (<http://www.openarchives.org/OAI/openarchivesprotocol.html>).

c. METS schema is a standard for encoding descriptive, administrative, and structural metadata regarding objects within a digital library, 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 (<http://www.loc.gov/standards/mets/>).

d. Table of Core Metadata Elements for *Library of Congress Digital Repository Development*:

|                        |                                |                                 |                                  |
|------------------------|--------------------------------|---------------------------------|----------------------------------|
| 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 reformatting\_information reformatting\_guidelines  
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  
(<http://lcweb.loc.gov/standards/metable.html>)

#### **IV. 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 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 InstrDL: 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 (Science, Math, Engineering and Technology Education) is a vast dynamic online library and portal of services that "opens up the worlds of science, mathematics, engineering and technology education to teachers and students anytime, anyplace" (<http://www.smete.org>);
- GEM (Gateway to Educational Materials) provides educators for "quick and easy access to thousands of educational resources found on various federal, state, university, non-profit, and commercial Internet sites" ([www.thegateway.org](http://www.thegateway.org));
- MERLOT (Multimedia Educational Resource for Learning and Online Teaching) is "a free, open resource designed primarily for higher education" ([www.merlot.org](http://www.merlot.org));
- NEEDS (A Digital Library for Engineering Education) is a digital library of learning resources for engineering education (<http://www.needs.org/needs/index.jhtml>);
- ERIC (Educational Resources Information Center) is a nation-wide information network designed to provide access to education literature "that contains more than 1 million bibliographic records of journal articles, research reports, curriculum and teaching guides, conference papers, and books" (<http://www.eric.ed.gov/>).

The later category is represented by many subject-oriented DL as: Education Instructional Library - American Society for Microbiology (<http://www.asmsa.org/edusrc/library/>), Peir.net - Pathology Education Instructional Resource (<http://peir.path.uab.edu/>), Teaching American History in Louisiana (<http://diglib.lsu.edu/TAH.nsf/Web/TAH>), Mathematical Sciences Digital Library -

Mathematical Association of America (<http://www.mathdl.org/>), BIOME - a searchable catalogue of resources for health and life sciences (<http://biome.ac.uk>) etc.

Both types of DLs 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 construction of sound instructional systems. Thus very few of them provide some links to general scientific papers about instruction issues or to some sample curricula.

**Scholnet** - an European project for Developing a Digital Library Testbed to Support Networked Scholarly Communities

### *Abstract*

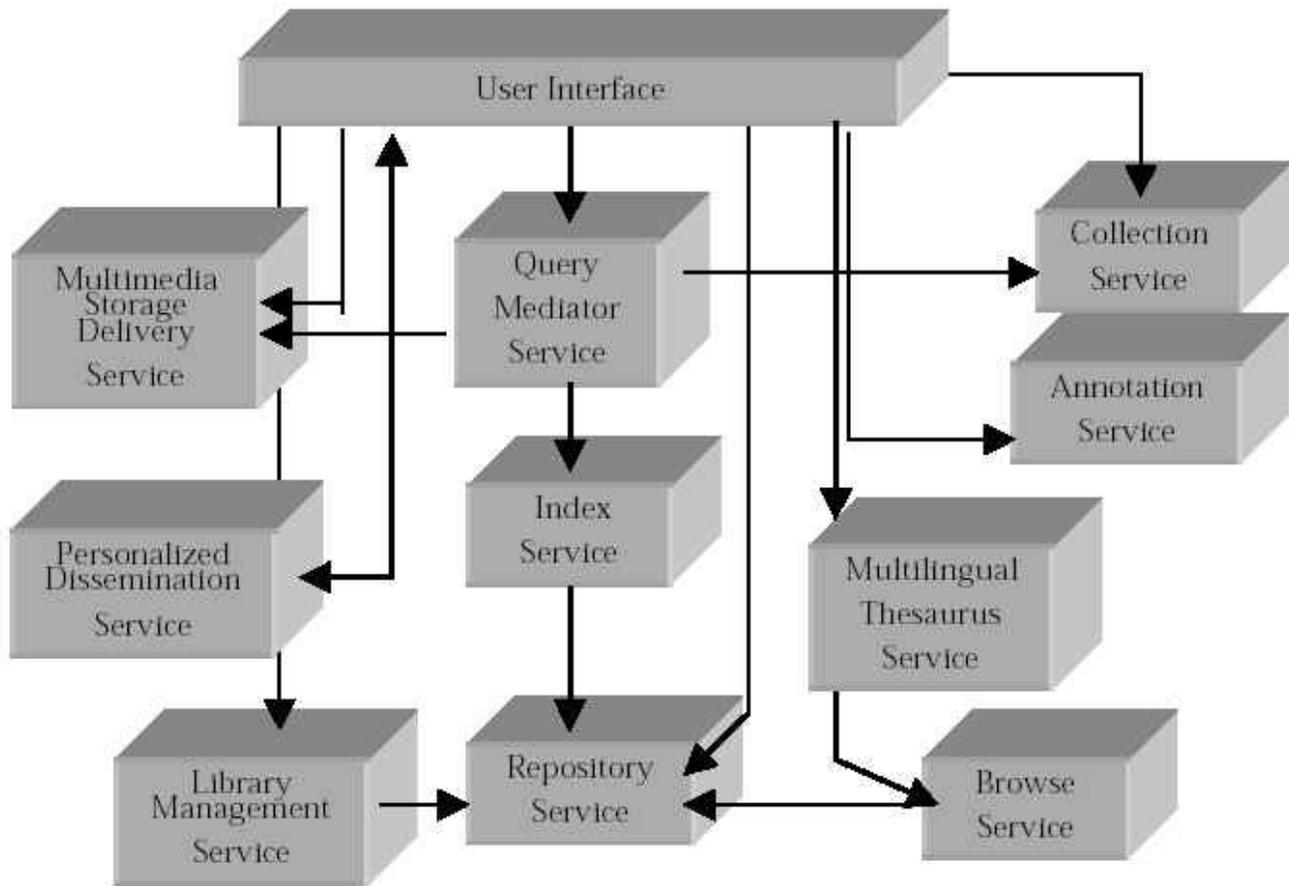
The Scholnet project aims at building a digital library infrastructure for supporting communication and collaboration among networked scholarly communities. In addition to the provision of standard digital library capabilities for information acquisition, description, archiving, access, search, and dissemination, this infrastructure will provide support for non-textual data types, hypermedia annotation, cross-language search and retrieval, and personalised information dissemination. From the technical point of view, Scholnet is being built by augmenting an existing federated digital library system, OpenDLib, with modules that implement non-standard digital library 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 digital library infrastructure serving the Working Groups of the European Consortium for Informatics and Applied Mathematics.

### *Objectives*

The aim of Scholnet is to build a new generation digital library (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 digital library services but also support for non-textual documents, hypermedia annotation, cross-language search and retrieval, and personalised 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 which will permit to satisfy the specific needs of the different scholarly communities.



A schematic representation of the Scholnet open architecture

### *Testbed*

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 (<http://www.ercim.org>) extended by the members of the DELOS Network of Excellence (NoE) on Digital Libraries (<http://www.ercim.org/delos>) and the Clarity project language information community (<http://http://clarity.shef.ac.uk>). Each testbed will be fed with the documents in use by the corresponding community. These documents consist of textual documentation, such as technical reports, project deliverables, workshop proceedings, and multimedia composite documents, such as synchronised videos and slides of seminars, tutorial, demos, etc.

### *Applications*

The Scholnet digital library 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.

### *Innovation*

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 a 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.

The commencement date of Scholnet was November 2000. The implementation of the system will be completed on May 2002.

## **V. A possible solution**

*A non-authoritative educational metadata ontology for filtering and recommending learning objects*  
M. M. Recker, D. A. Wiley (<http://wiley.ed.usu.edu/docs/non-authoritative.pdf>)

Digital libraries populated with learning objects are becoming popular tools in the creation of instructional technologies. 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 we argue 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, we propose a system that includes multi-record, non-authoritative metadata focused on the surrounding instructional context of learning objects.

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'. Examples of such educational digital libraries include [www.smete.org](http://www.smete.org), which offers a comprehensive collection of science, math, engineering and technology (SMETE) education content and services to learners, educators, and academic policy-makers (Muramatsu, 2000). In Europe, the ARIADNE project has been developing a Europe-wide federation of repositories of multilingual, digital, pedagogical resources.

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, we call these '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.

In this paper we examine key assumptions underlying the design of an educational digital library coupled with a metadata structure. In particular, we analyze the fundamental notion that a **learning object 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, this paper analyzes the extent to which 'authoritative' metadata support discovery and the instructional reuse of learning objects.

As we explain, our analysis suggests that in addition to 'authoritative' meta-information, a metadata structure must also incorporate what we 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. We 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 wish to specifically address and capture both the former and latter properties in order to support learning object reuse. We also argue 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 learning objects.

As we explain in the next section, we believe 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). 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 <http://alteredvista.usu.edu/>. 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.

### **Implementation within the Instructional Architect**

The Instructional Architect is a system that authors are currently designing and implementing, which incorporates their ideas based on non-authoritative metadata structures. 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 ([www.smete.org](http://www.smete.org)), National Library of Virtual Interactive Mathematics ([matti.usu.edu](http://matti.usu.edu)), National Science, Mathematics, Engineering, and Technology Digital Library ([www.nsd1.org](http://www.nsd1.org)). (<http://ia.usu.edu/>).

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, and Recommendation, Combination, and Reflection Tool. The function of each of these tools and the role of non-authoritative metadata are described below.

*Discovery Tool* 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, ([www.smete.org](http://www.smete.org)), 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 (e.g., <http://www.dogpile.com/>) 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. As previously discussed, these metrics are based on a model derived in our prior research. In particular, we 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.

### *Combination Tool*

The Combination Tool allows the user to contextualize the learning objects selected in the PIRT. The tool presents the user with the opportunity to sequence the objects 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 (1999) 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.

### *Reflection Tool*

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. In this manner, 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, 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.

In this paper, authors 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 we have called non-authoritative data elements to be included. These, we argue, 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.

This paper 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 digital library 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.