Expanding Access to Distance Learning using Learning Objects

Fernanda Campos 1,2, Regina Braga 1,2, Neide Santos 3, Ana Cláudia Souza 1,2

1 Knowledge Engineering Research Center
2 Computer Science Program – Federal University of Juiz de Fora – Brazil
3 Computer Science Program – State University of Rio de Janeiro – Brazil

This work describes BROAD, a set of learning object metadata, focusing on learning criteria that refines and extends current educational metadata and suggests a check list with information about learning objects usage scenario. It firstly argues learning objects and a metadata standard, presenting the most widely used metadata models, and then presents BROAD, our metadata basic schema, which includes elements to register the learning objects educational features. The conclusions summarize the work main contributions and point out future perspectives and researches.

Keywords: Learning objects. Metadata. E-learning.

1. Introduction

Education is an important route for social mobility and it is a key agent for social and technological development. Given the importance of expanding the education supply, many countries, like Brazil, are investing in democratizing access to education via distance learning. Our country has continental dimensions, with large population and unequal provision of social benefits, including the provision of education. Distance learning has been the government response to support the reversal of this scenario. However the necessary expansion of distance learning collides with the need for available tools, courses and classes to be used and reused on a large scale in different software platforms.

Moreover, nowadays there are many resources available on the Internet waiting to be reused. The growth of distance learning activities has been accompanied by a proliferation of data, learning objects (LO) and tools. This new setting brings new challenges, such as how to locate these resources, how to organize them, how to share and reuse successful learning objects and how to provide interoperability among data and tools from different platforms, so they are used by people with different backgrounds and needs. In this sense, Computers in Education community is looking for an infrastructure that enables the design, reuse, annotation, validation and sharing of computing artifacts, among them, the learning objects.

LO localization and retrieval require their appropriate register using a robust metadata model able to describe it fully and correctly, in order to facilitate the use. In LO domain, metadata describe relevant characteristics that are used for LO cataloging in repositories of reusable learning objects, which can be retrieved later through search engines or used by learning management systems (LMS) for composing learning units. The reusability of learning objects shows their potential to accelerate the preparation of distance courses and classes, thus help to increase the supply of education. Although there are many available metadata models, as will be discussed in this chapter, they almost always are extensive and complex and often neglect the educational aspects involved in LO.

The aim of this chapter is to describe BROAD (Search and Recovery of Distance Learning Objects, in Portuguese, Busca e Recuperação de Objetos de Aprendizagem a Distância), a set of learning object metadata, focusing on learning criteria aiming to ensure more than the traditional educational metadata, but also a check list with information about the learning object usage scenario. With this purpose, the chapter firstly argues learning objects and metadata, presenting the most widely used metadata models, then presents BROAD, our metadata basic schema, which includes elements to register the learning objects educational features.

2. Learning Objects

In distance learning area, there are many artifacts to be shared and reused by software developers, in particular, learning materials and learning objects. In the specific field of e-learning, these artifacts are, for example, distance learning content, scientific publications, technical reports, desktop applications or Web services (software applications, such as tutorials, simulations, games, etc...) A key point is how to find artifacts in available repositories on the Web. One solution is to develop software architecture with software agents communicating among them, using the vocabulary met in ontology for the domain of learning objects, and being endowed with the ability to retrieve learning objects registered according to a metadata standard. This kind of system is conceptually able to retrieve learning objects, by means of ontological annotations and intelligent mechanisms that act on those annotations.

The main goal of our research is to develop a computational architecture with software agents that intercommunicate from ontology for learning objects domain and that are able to retrieve learning objects registered from a solid metadata standard and stored in LO repository. To reach this goal, we must develop an ontology of learning objects that ensure interoperability with other domain ontologies. It can be used in computing applications that require semantics
navigation to register and search for artifacts of learning objects. Ontology can also be useful in defining and evaluating metadata for learning objects.

E-Learning is a comprehensive domain that encompasses forms of technology-enhanced learning such as online or Web-based learning. The fast grow of new information technologies has increased the interest in educational resources, or artifacts, on the Web. These artifacts are described as learning objects (LO), which promise wide reuse and automation. LO is a central concept of most current research in the area of Web-based education, and many institutions are dedicated to its research and standardization (Wang, Fang and Fan, 2008). The concept of LO is based on instructional technology and computer science advances (Clyde, 2004). The instructional technology has been a driver of change towards a process of student-centered learning, encouraging problem-based learning and independent and active learning. Computer science, in its turn, has contributed with ideas associated with object-oriented programming. The object-oriented approach is based on creation of digital components (called "objects") that can be used and reused in different contexts and even for different purposes.

Wiley (2000) describes learning object as small pieces of reusable educational resources. These objects are building blocks for highly interoperable and reusable content centered e-learning activities, based on shared specifications and standards previously certified (A Networker, 2003, in Clyde, 2004). A learning object standard specifies its syntax and semantics, defined as the attributes needed to adequately describe a LO (http://ltsc.ieee.org/wg12/index.html).

Examples of LO include multimedia content, instructional content, learning objectives, educational software, software tools, people, organizations, technical papers and research reports. The field guide to learning objects, compiled by the American Society for Training and Development, lists the following types of learning objects: class (a combination of text, graphics, animations, audio, questions and exercises), articles, case studies, discussion forums, simulations, role playing, simulation software, research projects and performance tests (ASTD and SmartForce, 2002).

Learning objects are cataloged as metadata, which describe all LO data, gathering a set of characteristics and attributes that represent or describe an object. Metadata typically are designed to locate, evaluate, discover and analyze the object to which they refer. There are many metadata to be registered about a learning object, since they describe relevant characteristics that are used for their cataloging in reusable learning objects repositories, which can be retrieved later through search engines or used by learning management systems (LMS) for composing learning units.

Standardizing LO metadata requires some metadata standard, since a learning object is generally identified by a set of metadata descriptors, such as those proposed by LOM (Learning Object Metadata) (LTSC, 2010) and SCORM (Sharable Content Object Reference Model) [http://www.scorm.com/]. Data elements that constitute an instance of LO metadata are organized in a hierarchy, providing information on many categories as general characteristics, life cycle, meta-metadata, technical requirements, educational characteristics, intellectual property and relations between other LO, annotations and classification system for LO.

The Advanced Distributed Learning cites four basic requirements that a Learning Object must meet to be reused (ADL, 2010):

- Accessibility- Ability to easily locate and access to be used in multiple locations
- Interoperability- Ability to have educational components developed in one system and use them on another system.
- Durability- Ability to support technological changes over time without the need for reconfiguration or recoding
- Reusability- Ability to reuse instructional components in other applications, classes, courses and contexts.

For cataloging learning objects aiming at later localization and reuse, many metadata schemes are being proposed, as shown in the next section of this chapter.

3. Metadata Standards for Learning Objects

Several organizations propose standards to better characterize learning objects metadata, such as Dublin Core, ARIADNE (Alliance of Remote and Instructional Authoring Distribution Networks for Europe), LOM (Learning Object Metadata), SCORM (Sharable Content Object Reference Model) and, more recently the Brazilian proposal for standardization OBAA (Agents-based Learning Objects).

a) The Dublin Core standard (http://dublincore.org/) is a metadata schema that aims to describe digital objects, such as videos, sounds, images, texts and web sites. Its applications use XML and RDF (Resource Description Framework) and the Dublin Core Metadata Element Set (DCMES) consists of fifteen metadata elements: Title; Creator; Subject; Description; Publisher; Contributor; Date; Type; Format; Identifier; Source; Language; Relation; Coverage; and, Rights.

b) In ARIADNE standard [http://www.ariadne-eu.org/], the metadata schema is organized into the following categories of descriptors that are presented in a logical sequence as mandatory for any educational resource to be indexed: Resource general information; Resource semantic; Pedagogical attributes; Technical features; Use conditions; and, Meta-metadata.

c) Sharable Content Object Reference Model (SCORM) is a collection of standards and specifications for e-learning. It defines communications between client side content and a host system called the run-time environment, which is
supported by a learning management system. SCORM also defines how content may be packaged. The new version, SCORM 2004, used the idea of sequencing, which is a set of rules that specifies the order in which a learner may access content objects. The standard uses XML, and it is based on the results of work done by IMS and Ariadne. SCORM stands for Sharable Content Object Reference Model. Sharable Content Object indicates that SCORM is all about creating units of online training material that can be shared across systems. SCORM defines how to create sharable content objects (SCOs) that can be reused in different systems and contexts (http://scorm.com/scorm-explained/).

d) Learning Object Metadata (LOM) is a data model, usually encoded in XML, used to describe a learning object and similar digital resources used to support learning. The purpose of learning object metadata is to support the reusability of learning objects, to aid discoverability, and to facilitate their interoperability, usually in the context of online a learning management system (LMS). The IEEE 1484.12.1 – 2002 Standard for Learning Object Metadata is an internationally-recognized open standard for the description of LO. Relevant attributes of learning objects to be described include: type of object; author; owner; terms of distribution; format; and pedagogical attributes, such as teaching or interaction style. LOM aims to facilitate search, evaluation and use of LO, and facilitate the accessibility and interoperability. LOM standards favor the minimum set of attributes needed to allow these Learning Objects to be managed, located and evaluated. For each data element, the base schema defines:

- Name: the name by which the data element is referenced;
- Explanation: The definition of data element;
- Size: the number of allowed values;
- Order: the order of values is significant (only applicable for data elements with multiple values);
- Area of value: the set of allowed values for the data element - typically in the form of a vocabulary or a reference to another standard;
- Type of data: a set of distinct values;
- Example: an illustrative example.

Depending of the case, the LO may also include pedagogical attributes such as interaction style, level of instruction and desirable prerequisites. As will be shown in section 4 of this chapter, BROAD standard uses a subset of elements of LOM standard.

e) The Agent-based Learning Objects Metadata Standard (OBAA) is a Brazilian initiative towards a standard for learning object. The goal is to create a metadata standard compatible with the LOM standard, but enabling the interoperability of LO into Web platforms, digital TV and mobile devices, and supports accessibility requirements for people with special needs and record educational information specific to the Brazilian context (Bez, Silva, Primo and Bordignon, 2009). OBAA extends IEEE LOM because the widespread acceptance of it in the academic environment and the ease of adjusting its metadata, allowing the insertion of new categories and items in existing categories. The new elements aim to meet Brazilian requirements in terms of technology, education, accessibility and segmentation. BROAD standard also considers some OBAA categories.

Related works on the reuse of learning objects usually adopt the IEEE LOM standards. The guidelines CanCore (http://cancore.athabascau.ca/en/), for example, were developed and structured around the nine categories proposed by LOM. The work of Knight, Gasevic and Richards (2005; 2006) also uses the LOM standard and considers the information granularity (fragment content, the content object itself and OA), the educational role (definition, example, keyword, etc), and presentation context (exercise, simulation, questionnaire, diagram, picture, graphic, content slides, table, narrative text, exam, experiment, etc) for describing these objects. Araújo (2003) has developed a platform for learning materials recovery from the LOM categories. The work of Gomes, Gadelha e Castro Junior (2009) also uses the LOM standard, but also uses Dublin Core for the construction of functional learning objects. Functional Learning Objects are computational artifacts having functionality that enables interaction between entities, whether digital or not, being used/reused in the mediation of the teaching-learning process. This interaction can occur between man-machine, man-man or machine-machine, with automated agents acting without the participation of a human agent.

Based on LOM and OBAA standards and on our needs to register learning objects to support searches of LO in our BROADWS architecture, the metadata standard BROAD is proposed.

4. BROAD: An Educational Proposal for Learning Objects Metadata

Metadata BROAD has emerged from extensive literature review and careful analysis of other patterns available for cataloging LO in Web repositories. Building BROAD has comprised three stages: firstly we were selected the essential metadata; in a second stage, we were defined educational metadata and in the third and final stage, we were selected a set of quality characteristics to be present in LO. The goals of stages 2 and 3 were not only expand the current metadata set, but also provide users of our LO repo.

4.1 Essential Metadata

LOM and OBAA standards are the most complete standards and they are very similar. The LOM comprises a hierarchy of elements. At the first level, there are nine categories, each of which contains sub-elements; these sub-elements may
be simple elements that hold data, or may themselves be aggregate elements, which contain further sub-elements. Its nine categories for cataloging LO are:
1) General category groups the general information that describes the learning object as a whole.
2) 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.
3) Meta-Metadata category groups information about the metadata instance itself (rather than the learning object that the metadata instance describes).
4) The Technical category groups the technical requirements and technical characteristics of the learning object.
5) Educational category groups the educational and pedagogic characteristics of the learning object.
6) Rights category groups the intellectual property rights and conditions of use for the learning object.
7) Relation category groups features that define the relationship between the learning object and other related learning objects.
8) Annotation category provides comments on the educational use of the learning object and provides information on when and by whom the comments were created.
9) Classification category describes this learning object in relation to a particular classification system.

OBAA offers eleven categories, extending LOM standards by proposing two new metadata: Accessibility and Segment. In addition, it extends the data schema of categories Educational characteristics and Technical requirements.

As mentioned, available patterns are extensive and complex, inhibiting their widespread adoption. One issue to be investigated is whether it is possible to extract from the set of metadata categories of current standards, a subset of metadata considered essential. In our point of view, seven metadata, described by several sub-metadata, can be considered essential:
1) General – comprises LO general features.
2) Life Cycle – groups features related to the current status of LO.
3) Technical – includes LO technical features.
4) Education – comprises LO educational characteristics.
5) Rights - groups LO copyright characteristics.
6) Classification – includes items that classify the LO.
7) Accessibility – describes the LO accessibility features.

Figure 1 represents the first level of BROAD and figure 2 offers a complete overview.

Fig 1. BROAD Metadata - 1st level

The main contribution of BROAD standard is to extend the educational elements of the current standards and this extension is highlighted in red in Figure 2.
4.2 Educational Metadata

During our research, we consider that the registration of LO could include a more detailed and qualitatively richer educational information, in order to improve LO retrieval. BROAD extends the educational metadata present in LOM and OBAA standards and describes them through a set of sub-metadata (table 1). This category allows the description of the educational characteristics that is typically used by teachers, administrators, authors and students.

BROAD proposes an explosion in the interactivity element by describing three new sub-elements: Perception, Co-presence and Reciprocity.

Fig 2. BROAD Metadata – general overview
## Table 1. BROAD: Educational Metadata

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Interactivity type</td>
<td>Type of LO interactivity</td>
<td>Active, Expositive, Mixed.</td>
</tr>
<tr>
<td>2. Type</td>
<td>File type</td>
<td>Drill-and-practice; Simulation, Questionnaire; Diagram; Figure; Graphics; Presentation slides; Sheets; Text; Exam; Experiment; and so on.</td>
</tr>
<tr>
<td>3. Interactivity level</td>
<td>Interactivity level is related to the degree in which student can influence the appearance or behavior of the component</td>
<td>Very low; Low; Medium; High; Very high.</td>
</tr>
<tr>
<td>4. End user</td>
<td>Represents the primary user so that the object was designed</td>
<td>Teacher. Author. Student. Manager.</td>
</tr>
<tr>
<td>6. Average age</td>
<td>Age range</td>
<td></td>
</tr>
<tr>
<td>9. Interaction</td>
<td>Specification of the educational interaction proposed by the LO and its user.</td>
<td></td>
</tr>
<tr>
<td>9.1.2. Co-presence</td>
<td>Specification of the use of mechanisms that help the identification of other users in the environment.</td>
<td></td>
</tr>
<tr>
<td>9.1.3. Reciprocity</td>
<td>Kind of relationship among users, necessary for the operation of the LO.</td>
<td></td>
</tr>
</tbody>
</table>

### 4.3 Learning Objects Educational Quality

The educational quality of learning objects is not the focus of our work, but it is an important point in the research on LO. In this direction, a list of LO quality characteristics was drawn, from the literature review, reflecting the requirements for choosing a learning object for a pre-established usage scenario.

The goal was to select a set of attributes that express the vision of the user / teacher about the quality of the learning object within a context of use, called quality in use in accordance with ISO / IEC 9126 (http://www.iso.org/iso/catalogue_detail.htm). This view of quality evaluates the degree, with which users can achieve their goals in a particular environment, with effectiveness, productivity, safety and satisfaction, instead of evaluating the properties of the software itself.

The quality characteristics that compose the list were validated with six education professionals, experts in creating and using learning objects. From an initial list of forty-seven LO quality characteristics, fourteen of them were considered as essential.

1) Based on a pedagogical proposal
2) Appropriated to the teacher needs and goals
3) Be easy to access information
4) Worked with contextualized content
5) Cohesion of language and grammar
6) Clear description of the information
7) Interactivity encouragement
8) Insertion in an Educational Project, a teaching plan or an Educational Proposal
9) Promote the exchange of experiences among students and the cooperative work
10) Language according to the student understanding level
11) Balance among animation, sound, colors and other media
12) Relevance to the curriculum
13) Content correctness

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Adaptability

The computational environment to promote LO search and retrieval is BROADWS. A general vision of the BROADWS architecture is presented in Figure 3.

This architecture uses concepts of ontology repository and semantic web services. BROADWS aims to provide an infrastructure to register and query LOs, according to BROAD metadata. This allows repositories distribution and facilitates its use in workflows. The architecture considers three different tiers:

- **BROADWS (Middle Tier):** implemented as a RESTful web service, it can be installed in different sites, allowing the distribution of repositories, and it is independent of the interface that will access services, allowing its integration with existing tools and frameworks.

- **Backend Tier:** it is the service tier, used by the BROADWS to access the relational database (BROADDB) where the ontology (classes and individuals – the LOs) is stored.

- **Client Tier:** implements the user interface and it can be developed in any language or framework as a REST client.

The architecture offers four services to its users:

- **Registry (Form):** Get the LO data from a HTTP POST, possibly through a HTML Form. The data is stored at a relational database at BROADDB.

- **Query (SQL):** The user makes a SQL query and receives, as a result, LOs which matches the query.

- **Registry (ontology):** Based on the URI given by the user, the LO, expressed as an OWL model, is recovered and, using inference mechanisms, the model is stored in a database;

- **Query (SPARQL):** The user makes a SPARQL query and receives, as a result, individuals (LOs) from ontology stored at database which matches the query.

The BROADWS services are distributed in three layers:

1. **Client Manager:** Responsible for users interaction, implementing the Facade design pattern. Its purpose is to provide a single interface with clients of system, so customers do not have access to the internal structure of the BROADWS.

2. **Storage Manager:** Responsible for ontology storage/recovery in the database, and queries carried out by the user, encapsulating the access to database.

3. **Ontology Manager:** Responsible for inference on the models, as well as for providing an API to access BROAD ontology.

The use of the complete BROADWS infrastructure depends on the development of end users applications, using graphical interfaces and encapsulating its services. BROADWS expectation is that users get more accurate responses to their requests. Thus, the focus of the work is to minimize the effort of selecting educational metadata and provide a set of metadata elements that identifies more detailed features of the educational possibilities of using a learning object. The registration, search and retrieval service was developed as a Web service and will soon be available in Moodle.

5. Conclusions

The provision of education via distance learning is an important goal for developing countries like Brazil, since education is a potential means of economic and social mobility. Its expansion can be based on the availability of distance learning platforms and courses. In this sense, the use of learning objects can be a success factor. Locate, retrieve and use learning objects, however, has been a bottleneck in its rapid spread. BROAD metadata standard and BROADWS architecture represent a contribution to this issue.

Metadata for learning objects is a central subject for their recovery and use. A learning object metadata standard usually focuses on the minimal set of attributes needed to allow these LO to be managed, located, and evaluated. Relevant attributes of LO to be described include type of object, author, owner, terms of distribution, and format. Where
applicable, Learning Object Metadata may also include pedagogical attributes such as teaching or interaction style, grade level, mastery level, and prerequisites.

The basic premise of our work is as, from the current standards (e.g. LOM), to extract a subset of metadata considered as essential. In our point of view, seven metadata categories are essential: General (LO general features), Life Cycle (characteristics relating to the LO current situation) Technical (LO technical features), Rights (Copyright features), Classification (Items that classify the LO) and Accessibility (LO accessibility features). Other available metadata standards include educational metadata, but our proposal extends it to better describe educational relevant features to be presented in the description of a LO. Our educational metadata is described through nine sub-metadata: Interactivity type, Type, Interactivity level, End User, Context, Average age, Difficulty level, Content type and Interaction that includes Perception, dividing into the elements Co-presence and Reciprocity.

A contribution of our work is to propose an initial model for LO registration and search, which will be used in our BROADWS architecture. This architecture works some Web Semantics technologies, such as domain ontology, software agents, semantic web services and workflow in order to locate and retrieve LO from Web repositories of heterogeneous data.

**References**


