From Chasqui to Chasqui II: an Evolution in the Conceptualization of Virtual Objects

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Abstract: This paper describes the evolution experienced by the concept of *virtual object*. This concept has evolved in the context of several e-learning projects developed by the group of *Software Engineering and Artificial Intelligence* (ISIA) at the *Complutense University of Madrid* (UCM). The initial goal of the first of these projects, the *Chasqui* Project, was to facilitate the didactic and scientific use of the real objects belonging to the *Archaeology Museum* of the *Department of American History II* at this University. As a concept intended for organizing the learning and scientific information, the concept of virtual object has undergone an important transformation as it has been applied to two other projects: the virtualization of the *Museum of the History of Computing* at the *School of Computer Science* at the same university, and the *Chasqui II* project, an improved version of the first *Chasqui* which is now under development by the ISIA group and *Telefónica I+D* corporation.

Keywords: e-learning, virtual object, learning object, virtual museum, LCMS, virtual campus, authoring tool, web services, LOM, SCORM, IMS
Categories: K3.0, K3.1, K3.2

1 Introduction

The work presented in this paper is based on the lessons learned during the development of several e-learning projects focused on the usability and educational accessibility of real objects belonging to two museums at the *Complutense University of Madrid* (UCM): the *Antonio Ballesteros Archaeology Museum* at the *Department of American History II* and the *José García Santesmases Museum of the History of Computing* at the *School of Computer Science*.

The *Antonio Ballesteros* museum has several hundred archaeological and ethnographical objects from different American cultures. The process of identification, classification and analysis of these objects varies depending on various

factors. This department also has an archaeology laboratory and a rich variety of documental resources such as graphic and documental libraries (field logs, excavation diaries, slides, analyses and profiles of the objects and of the archaeological sites). However, due to their economic and scientific value and in order to prevent damage to these objects, the access to all this material is very restricted and can only take place with the simultaneous presence of teachers and students. In this context, the e-learning project *Chasqui*[1] [Fernández-Valmayor, 03][Chasqui] was proposed. *Chasqui* was a project developed jointly by the aforementioned department and the *Department of Computer Systems and Programming* at the same university. The main goal of this project was to let researchers, teachers and students get online access to all the material in the museum, and increasingly, to the material in the laboratory and documental libraries as well.

The success of the *Chasqui* virtual museum among both teachers and students was the main reason to start a new project, initially of similar characteristics, for the *José García Santesmases* museum [MIGS]. Physically, this museum of the history of computing is located at the *Computer Science School* and it exhibits several machines developed at the UCM between 1950 and 1975, several commercial computers that were used in the computation centre of the university since 1968, and other equipment donated by the university, private individuals, and other institutions. The museum also has different types of documental material, such as manuals, photos and research logs of the pioneers of computer science at the UCM. Most of these objects have great pedagogical value because they represent a comprehensive perspective of the evolution of computer science in Spain. However, educational access to the material exhibited in the museum is difficult because of the characteristics of this museum. Firstly, the equipment is located inside glass cabinets with informative cards that only describe some of the characteristics of this equipment. Secondly, the museum does not have staff to provide additional information about this equipment. Finally, there are no leaflets about the equipment, and only a small part of all the documental material that the museum has is exhibited in glass cabinets. In this context, and inspired by the *Chasqui* project, a project for the virtualization of this museum was proposed.

The rest of this paper is organized as follows: section 2 presents the concept of virtual object as it was defined and used in the first *Chasqui* project. Section 3 presents the evolution experienced by the concept as a result of the development of the *José Garcia Santesmases* virtual museum. Section 4 describes the most recent changes the concept has experienced, and the work under development to integrate virtual objects with authoring tools based on IMS specifications [IMS, 04]. Section 5 presents related work. Finally, section 6 presents some conclusions and future work.

2 Virtualization of the *Antonio Ballesteros* Museum of Archaeology: Virtual Objects

At its first stage, the main goal of the *Chasqui* project was the virtualization of the objects belonging to the *Antonio Ballesteros* Museum of Archaeology. However, as

[1] *Chasqui* means *messenger* in *Quechua*, the language spoken in the *Inca Empire*.

the project has evolved, the target of the process of virtualization has been not only the objects of the museum but also objects from other sections of the department, such as the laboratory and the graphic and documental libraries with technical reports and documents produced by department researchers, instructors, and students. From an educational point of view, the main assumption of the project was that all the aforementioned objects and resources have great pedagogical value that cannot be used in an efficient manner due to the restrictions posed in their access.

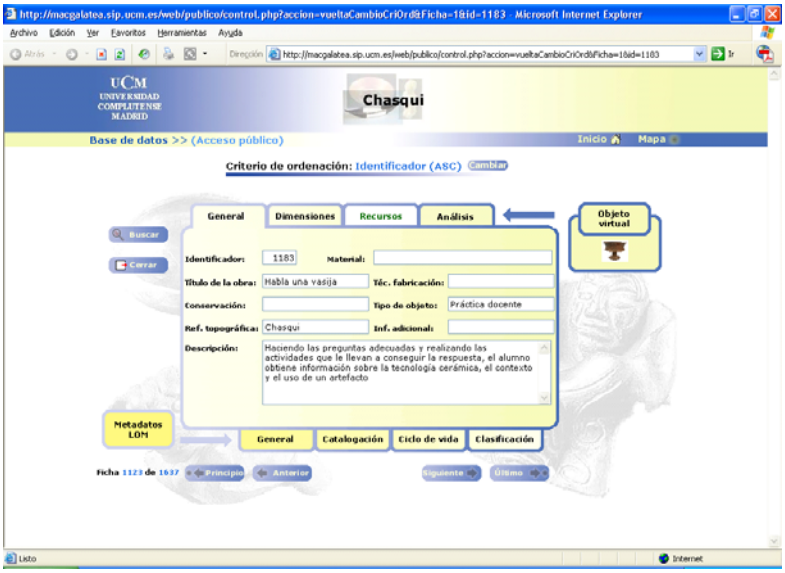

Figure 1. The Chasqui virtual museum

To facilitate the access of teachers and students to this material, the development of a software application called the *Chasqui* system was proposed (Figure 1). The main requisite of this application was to provide simple access to all the resources in the department, thus enabling the exploitation of all the educational and information potential of these resources. The application was initially conceived as a virtual museum annexed to the real museum of the department, but as the design and development of the application evolved, it has resulted in a tool which can handle not only the information about the objects but which can also help to study and establish the relations among them.

The main concept underlying the design of the *Chasqui* system is the concept of *virtual object* [Fernández-Valmayor, 03][Sierra, 05]. In essence, a virtual object is a digital object that is composed of (Figure 2):

- A set of *data* that describes all the physical and/or conceptual characteristics of the real object which can be of some educational value or which can be potentially useful for its scientific study. This set of characteristics is partitioned in subsets of related characteristics called *cards*.

- A set of *metadata* that describes and classifies the object from the learning point of view. In *Chasqui*, this metadata is described using a subset of standard *Learning Object Metadata* (LOM) [LOM, 02].
- A set of *resources*, which is a collection of virtual representations of some aspect, conceptual or physical, of the object. In *Chasqui*, these resources are digital files of different nature: text, image, audio or video files. Conceptually, these files can be further classified as: (i) files belonging to the object; (ii) files belonging to other virtual objects but that in some way are shared by the object; and (iii) the complete set of files of other virtual objects.

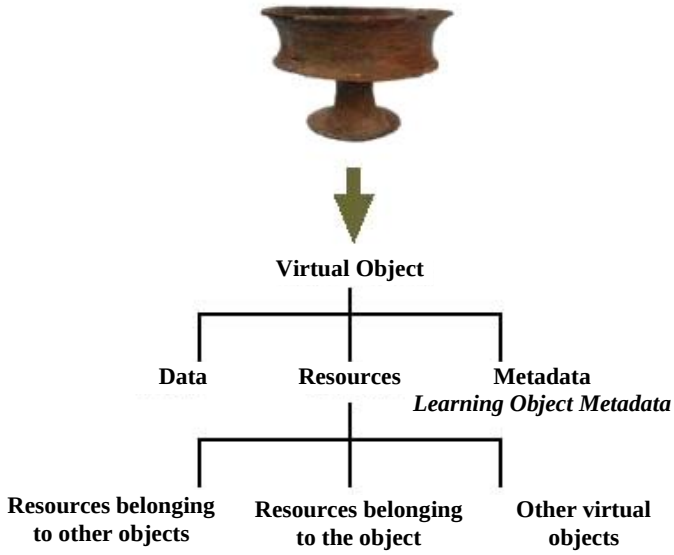

Figure 2. A real object and its representation using a virtual object

This model enables the definition of new composite virtual objects integrating other objects and/or resources in the museum which are related through some cultural characteristic or archaeological connection. The concept of virtual object can also be related to the concept of *learning object* as used by the e-learning community [Polsani, 03], and in particular as defined in proposals such as the *Sharable Content Object Reference Model* (SCORM) [SCORM, 04]. This way, the simplest virtual objects, whose resources include only multimedia files belonging to them, may be equivalent to SCORM *assets* (atomic objects). More complex virtual objects, whose resources include resources belonging to, and/or making reference to, other virtual objects, may be equivalent to SCORM *Shareable Content Objects* (SCOs)[2]

[2] Learning objects composed of simpler objects. They represent a module with an intended didactic meaning.

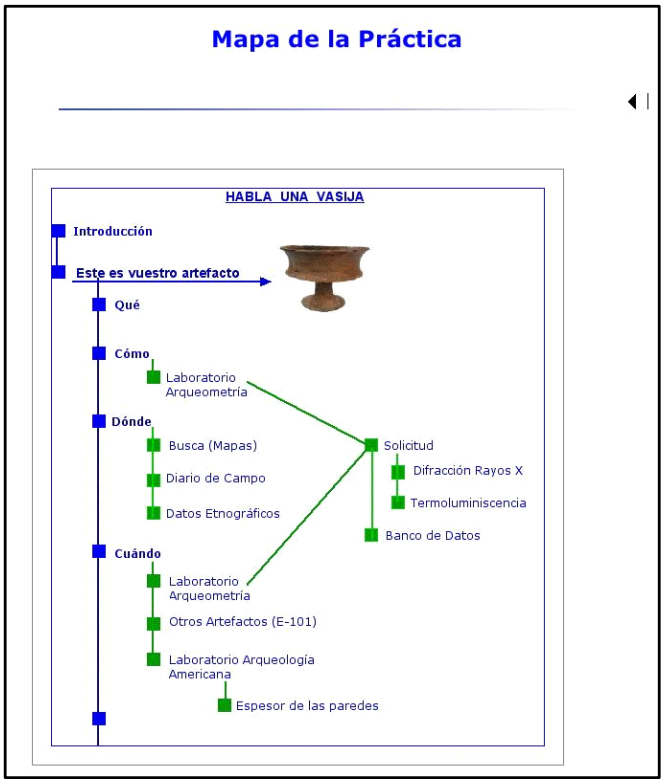

Figure 3. A work assignment for undergraduate students integrated into Chasqui as a virtual object.

In the *Chasqui* project, the virtual object's data and metadata are stored in a database server, and its associated resources are stored in the file system of this server (every virtual object has its own directory). Moreover, as was previously mentioned, simple and flexible access to the information included in the virtual objects was one of *Chasqui*'s requisites. Therefore, from the beginning, the system was conceived as a Web application where any browser could be used to access and manage all the information included in the museum, laboratory and libraries. This characteristic has allowed the use of *Chasqui* by teachers and students as a collaborative system for the definition of lessons, exercises and/or research logs represented in terms of virtual objects (Figure 3). *Chasqui* has also been integrated in the courses of the *Virtual Campus of the UCM* [VCUCM][Guinea, 04].

At present, *Chasqui* has been in use for more than two years, and contains more than 1,500 virtual objects. *Chasqui* is under a permanent validation process, and therefore, continuous improvements and changes are being made to the system.

3 Virtualization of the *García Santesmases* Museum of Computer Science: Packaged virtual objects

The main goal of the *Garcia Santesmases* virtual museum project was to implement a solution in order to facilitate the pedagogical use of the information contained in the elements of the real Museum of the History of Computing. Due to the great similarity between the underlying concepts of this scenario and those of the *Chasqui* project, the virtualization of the new museum was inspired by the same concepts and design principles used in *Chasqui*. Therefore, in this museum, the concept of virtual object was also used in order to organize the knowledge about real objects in the museum (Figure 4).

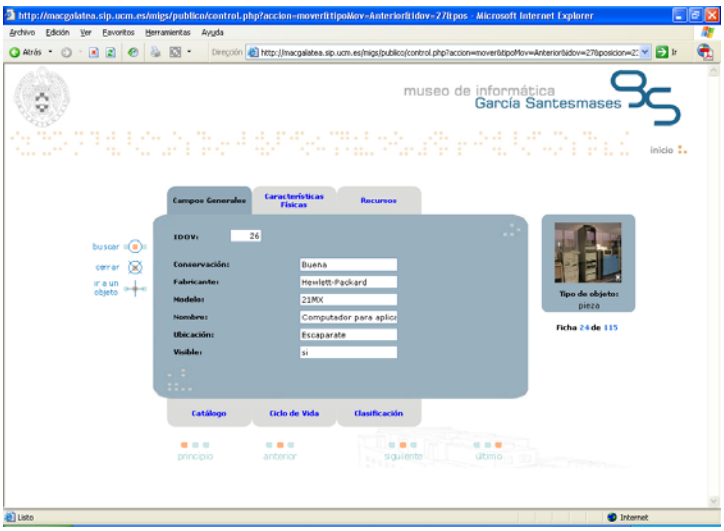

Figure 4. García Santesmases virtual museum

An additional goal in the new virtualization process was to solve some of the problems detected in the original design of the *Chasqui* application. These problems had posed some difficulties in the maintenance and use of the resources included in *Chasqui*. Basically, these problems can be summarized in two groups:

- *Maintenance of the coherence of information stored in the system.* In the *Chasqui* system, there are no validations of the format of the elements that compose virtual objects. In addition, there are no verifications regarding the dependencies established among these elements. In particular, dependencies established among the resources belonging to an object and used for another are not checked.
- *Lack of interoperability*. *Chasqui* was designed as an isolated system. Therefore, explicit mechanisms for the exportation/importation of virtual objects to/from other e-learning systems were not included.

During the virtualization of the computer science museum, and in order to overcome these shortcomings, the concept of virtual object used in *Chasqui* was

extended by using a packaging and validation mechanism of the information contained in the virtual objects. The IMS *Content Packaging Information Model* [IMS, 04], initially defined for learning objects, was adapted to the concept of virtual object. An IMS package is a self-contained entity, because it integrates all the resources that compose the learning object. In addition, IMS packaging has an XML [XML, 04] document called the *manifest*, which includes the metadata that describes the object and the dependencies among the elements that compose it. IMS content packaging avoids the previously enumerated shortcomings. Indeed:

- The manifest can be used as the basis for the development of validation mechanisms that make the maintenance of the coherence of the objects possible and therefore of the information contained in the whole museum.
- The packaging of virtual objects permits the importation and exportation of virtual objects, either to be used as individual elements or to be integrated in other learning systems.

Finally, inspired by the IMS specification, several functions for the packaging and unpackaging process of virtual objects have been defined in the computer science museum. The phases of this process are:

- Selection of the contents that compose the virtual object, and analysis of the dependencies among the resources of the object and among the resources of different objects.
- Selection of the metadata necessary to tag the chosen contents that will be included in the virtual object.
- Packaging of the virtual object.

4 Chasqui II: Distributed Virtual Objects

Based on our experiences with the virtualization of the aforementioned two museums and in collaboration with the *Telefónica I+D* corporation [TID] we have undertaken a project called *Chasqui* II, whose aim it is to extend these developments to broader scenarios.

The applications for the management of the virtual museums described in the previous sections are not directly reusable in other contexts because although they have similar principles, they have been developed to solve the specific problems that appear in each museum. In Chasqui II we have proposed the use of *web services* [Cerami, 02] to overcome these shortcomings. The resulting architecture is outlined in Figure 5. This architecture incorporates a web service-based programmatic interface, which provides a way to integrate applications and services in a neutral manner due to the use of XML standards such as *Simple Object Access Protocol* (SOAP) [SOAP, 03] (XML requests and responses to Chasqui II-web service) and *Web Services Description Language* (WSDL) [WSDL, 04] (XML definition of the interface, based on XML Schema). Currently, the web service enables the downloading and deletion of virtual objects from the system, the uploading of new virtual objects into the system, as well as the searching of virtual objects using the properties included in their data and their associated metadata. Virtual objects accepted and provided by this interface are packaged according to IMS. This web service interface can be enhanced with new functionalities, to permit a higher level of integration between Chasqui II and other repositories or final applications.

The web service-based interface facilitates the use of alternative access mechanisms (e.g. based on mobile devices) and also of alternative authoring tools. One of these tools is *IMSCP_UCM*, currently under development. IMSCP_UCM is an IMS based exploratory application for the generation of learning objects. IMSCP_UCM uses the structure defined by IMS for learning objects, and extends it in order to permit:

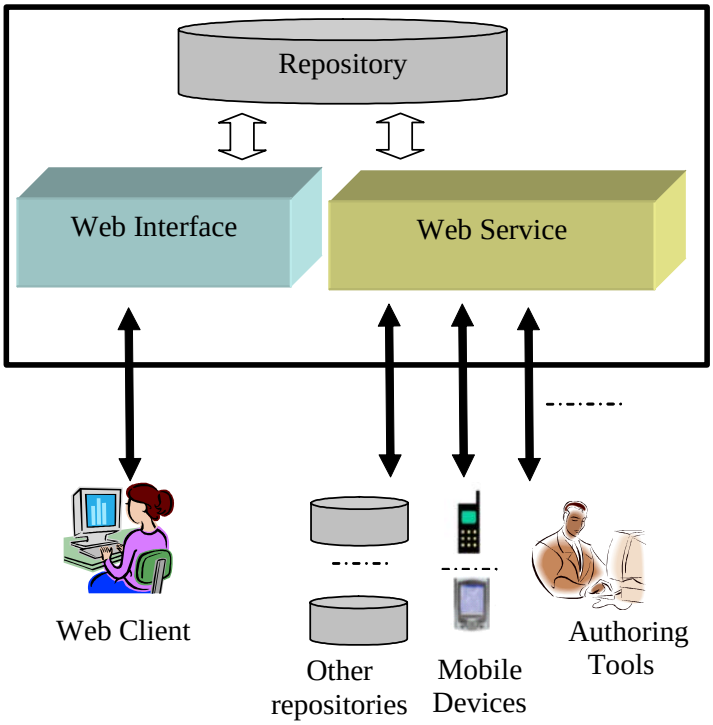

Figure 5. Proposal Chasqui II architecture for the Virtualization of academic museums

- *Object authoring*. The tool permits the creation of new virtual objects and their inclusion in a repository. For this purpose the tool enables the definition of their structure in terms of data, metadata and resources (internal or external). This function also allows for the *friendly* definition of objects' manifests.
- *Object retrieval and deletion*. The application allows the retrieval of objects from a repository by taking into account their identifiers. In addition, the deletion of the objects can be done by observing the dependencies among them.
- *Object visualization*. Retrieved objects can be visualized in the application graphic user interface.

- *Object packaging*. Virtual objects can be packaged according to the IMS format. These packages are zip files that contain the files that represent the resources of the object as well as its manifest. This package includes all the resources and virtual objects directly or indirectly related to the virtual object that is being packaged.

IMSCP_UCM will be able to be simultaneously connected to different repositories using the web service-based interface, thus promoting the integration of all these repositories in a distributed authoring scenario.

5 Related work

The efforts described in the present paper are related to some extent to the field of virtual museums. Virtual museums in archaeology have a long tradition. As described in [Barceló, 00], the concept of *virtual archaeology* was firstly proposed by Reilly [Reilly, 90], and it refers to the use of 3D computer models of ancient buildings and artifacts (e.g. [Hemminger, 05]). Regarding virtual museums in computer science [VMoC], in our opinion, most of these sites exhibit brief historical descriptions of some computer science-related product (e.g. [Atari]), or they provide hypermedia access to a database [Isakowitz 95] which contains the technical characteristics of previously mentioned computer-science related products (e.g. [HCM]).

One of the main differences between the work presented in this paper and the archaeological and computer science virtual museums is the emphasis on the use of the information that these systems provide. Archaeological and computer science virtual museums are mainly concerned with the *exposition of knowledge*: the exhibition of the virtualized objects and their technical characteristics. Our systems take care of this exposition of knowledge, but they also let users participate in the active and dynamic construction of this knowledge during the learning, teaching and research processes. Therefore, our systems also take care of the educational *use* and *reuse* of the virtual information that represents the real elements. The educational *use* of the virtual elements has led us to apply specialized techniques during the design of virtual object models for our museums [Fernández-Valmayor, 03][Sierra, 05] (e.g. hypermedia modeling [Navarro, 04] or domain-specific markup languages [Sierra, 04]). In addition and as previously mentioned, the educational *reuse* of these virtual elements has led us to consider web services technologies as well as e-learning standards.

Among the existing e-learning standards we have decided to use LOM and the IMS Content Packaging model. Nevertheless, they might be considered as supporting technologies instead of as the main concern of our efforts. Indeed, we are using LOM to attach metadata to our virtual objects, and we are using IMS packaging facilities to bundle together the different files associated with virtual objects during importation/exportation, but virtual objects *are not* a substitutive for any of these technologies, nor for other more general–purpose proposals like SCORM. Virtual objects should be considered a conceptual model for the informational items that arise in the domains considered during the development of Chasqui, MIGS and Chasqui II systems [Fernández-Valmayor, 03][Sierra, 05]. In addition, as demonstrated in the present paper, this model is subject to continuous evolution.

Finally, our work is also related to different proposals for the management of educational resources, and, in particular, with *Learning Management Systems* (LMS) [elementk, 03] and *Learning Content* Management *systems* (LCMS) [Chapman, 04]. The primary objective of a learning management system is to manage learners, keeping track of their progress and performance across all types of training activities, while a learning content management system manages content or learning objects that are served up to the right learner at the right time [LMSLCMS].

Taking into account these definitions, our systems are more similar to LCMSs than to LMSs. Indeed, they can be considered hybrid systems, between virtual museums and LCMSs. The main difference between our systems and LMSs is that, at present, our museums are not concerned with the users' progress through the browsing of the museums. Regarding LCMSs, at present, our systems do not include some of the educational capabilities of these systems such as, for example, learner collaboration. In any case, neither LMS nor LCMS provide the presentational and browsing capabilities of learning objects that our systems provide.

6 Conclusions and future work

This paper describes the evolution experienced by the concept of virtual object from its definition to the present. In addition, some of the more relevant technical questions involved in this evolution have been also described. Based on these practical experiences, we have established the power and flexibility of the concept, from both the software development and the educational point of view. The development of two museums and the extensive use that teachers and students have made of them support our claim. It is important to point out that an important component of the success of virtual objects as organizers of scientific and educational information is their practical conception. From the beginning, facilitating the use of these objects to teachers and students has been one of our main goals [Fernández-Valmayor, 03][Sierra, 05]. Large-scale maintenance and reusability have been the most important shortcomings of virtual objects. The packaging of virtual objects has improved the maintenance and interoperability of these elements. In addition, the use of web services has facilitated the reuse of virtual objects in heterogeneous e-learning environments.

Regarding virtual museums and LCMSs, Chasqui and MIGS can be considered hybrid systems. They are not concerned exclusively with the virtual displaying of real elements or with the educational characterization of learners and/or educational resources. Instead, these systems are concerned about an adequate virtual displaying of the real elements and about the appropriate educative use (and reuse) of the educational resources that populate our museums. Indeed, virtual objects are the vehicle to obtaining these goals.

The development of these hybrid systems that take into account characteristics from virtual museums and from LCMSs is one contribution to the work presented in this paper. Furthermore, in our opinion, the main contribution of our work is the formulation of a learning object model (virtual objects) characterizing the informational items that populate these hybrid systems. These virtual objects permit the virtualization of real elements, and the educative use and reuse of the virtualized characteristics of such real elements.

Currently we are working on the development and improvement of the virtual object authoring tools outlined in this paper. In addition, we expect to test the distribution of packaged virtual objects using web services in different learning applications under development, as well as to experiment with further evolutions of the concept of virtual object in new e-learning scenarios. As future work we are planning to further integrate our systems with the Virtual Campus of the UCM in order to enhance their functionality with some specific characteristics of LCMSs systems (e.g. learner collaboration).

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References

[Atari] The Atari Museum. http://www.atarimuseum.com/

[Barceló, 00] J. Barceló, M. Forte, D. Sander (eds.) Virtual Reality in Archaeology. Computer Applications and Quantitative Methods in Archaeology. British Archaeological Reports, International Series S843 (Oxford: British Archaeological Reports). http://www.learningsites.com/Support_pages/BFS_VRinA_intro.html

[Cerami, 02] Cerami, E. Web Services Essentials.O'Reilly.2002

[Chapman, 04] B. Chapman, S.O. Hall, LCMS 2004-2005 Report: Comparative Analysis of Enterprise Learning Content Management Systems. Brandon-Hall 2004.

[Chasqui] The Chasqui Virtual Museum
http://macgalatea.sip.ucm.es/web/principal/principal.html.

[elementk, 03] elementk, Learning Management Systems in the Work Environment.
http://www.elementk.com/downloads/lms_whitepaper.pdf

[Fernández-Valmayor, 03] A. Fernández-Valmayor, M. Guinea, M. Jiménez, A. Navarro, A. Sarasa, Virtual Objects: An Approach to Building Learning Objects in Archaeology. Computers and Education: Toward a Lifelong Learning Society. Kluwer Academic Publisher, The Netherlands, 2003

[Guinea, 04] M. Guinea, El Proyecto Chasqui (*The Chasqui Project*, in Spanish). Campus Virtual UCM. Editorial Complutense. Madrid, 2004

[HCM] Home Computer Museum, http://www.homecomputer.de/pages/f_gallery.html

[Hemminger, 05] B. Hemminger, G. Bolas, D. Schiff, Capturing Content for Virtual Museums: form Pieces to Exhibits. Journal of Digital Information 6 (1)
http://jodi.tamu.edu/Articles/v06/i01/Hemminger/. 2005.

[IMS, 04] IMS Content Packaging Information Model Version 1.1.4. www.imsglobal.org

[Isakowitz 95] T. Isakowitz, E.A. Stohr, P. Balasubramanian, RMM: a Methodology for Structured Hypermedia Design. Communications of the ACM 38(8). 1995.

[LMSLCMS] LMSs and LCMSs Demystified.
http://www.brandonhall.com/public/resources/lms_lcms/

[LOM, 02] IEEE Standard for Learning Object Metadata. *IEEE Standard 1484.12.1-2002*. 2002

[MIGS] The García Santesmases Virtual Museum http://www.fdi.ucm.es/migs/.

[Navarro, 04] A. Navarro, A. Fernández-Valmayor, B. Fernández-Manjón, J.L. Sierra, Conceptualization prototyping and process of hypermedia applications. International Journal of Software Engineering and Knowledge Engineering, 14(6), 565-602. 2004

[Polsani, 03] P.R. Polsani, Use and Abuse of Reusable Learning Objects. Journal of Digital Information 3(4). http://jodi.tamu.edu/Articles/v03/i04/Polsani/ 2003

[Reilly, 90] P. Reilly, Towards a virtual archaeology. Computers Applications in Archaeology. K. Lockyear and S. Rahtz (eds). (Oxford: British Archaeological Reports). 1990

[SCORM, 04] Shareable Content Object Reference Model SCORM. www.adlnet.org

[Sierra, 04] J.L. Sierra, A. Fernández-Valmayor, B. Fernández-Manjón, A. Navarro, ADDS: A Document-Oriented Approach for Application Development. Journal of Universal Computer Science 10(9). 1302-1324. 2004

[Sierra, 05] J.L. Sierra, A. Fernández-Valmayor, M. Guinea, H. Hernanz, A. Navarro, Building Repositories of Learning Objects in Specialized Domains: The Chasqui Approach.5th IEEE International Conference on Advanced Learning Technologies ICALT'05. Kaohsiung, Taiwan. July 5-8. 2005

[SOAP, 03] World Wide Web Consortium, Simple Object Access Protocol (SOAP) 1.2. http://www.w3.org/TR/soap/

[TID] Telefónica I+D Corporation. http://www.tid.es/

[VCUCM] Virtual Campus of the Universidad Complutense de Madrid. https://campusvirtual1.ucm.es/cv/

[VMoC] The Virtual Museum of Computing. http://vmoc.museophile.com/

[WSDL, 04] World Wide Web Consortium, Web Services Description Language (WSDL), http://www.w3.org/TR/2004/WD-wsdl20-20040803/

[XML, 04] World Wide Web Consortium, Extensible Markup Language (XML) 1.0 (Third Edition), http://www.w3.org/TR/2004/REC-xml-20040204/

Draft. Final version published in Journal of Universal Computer Science 11(9), 1518-1529